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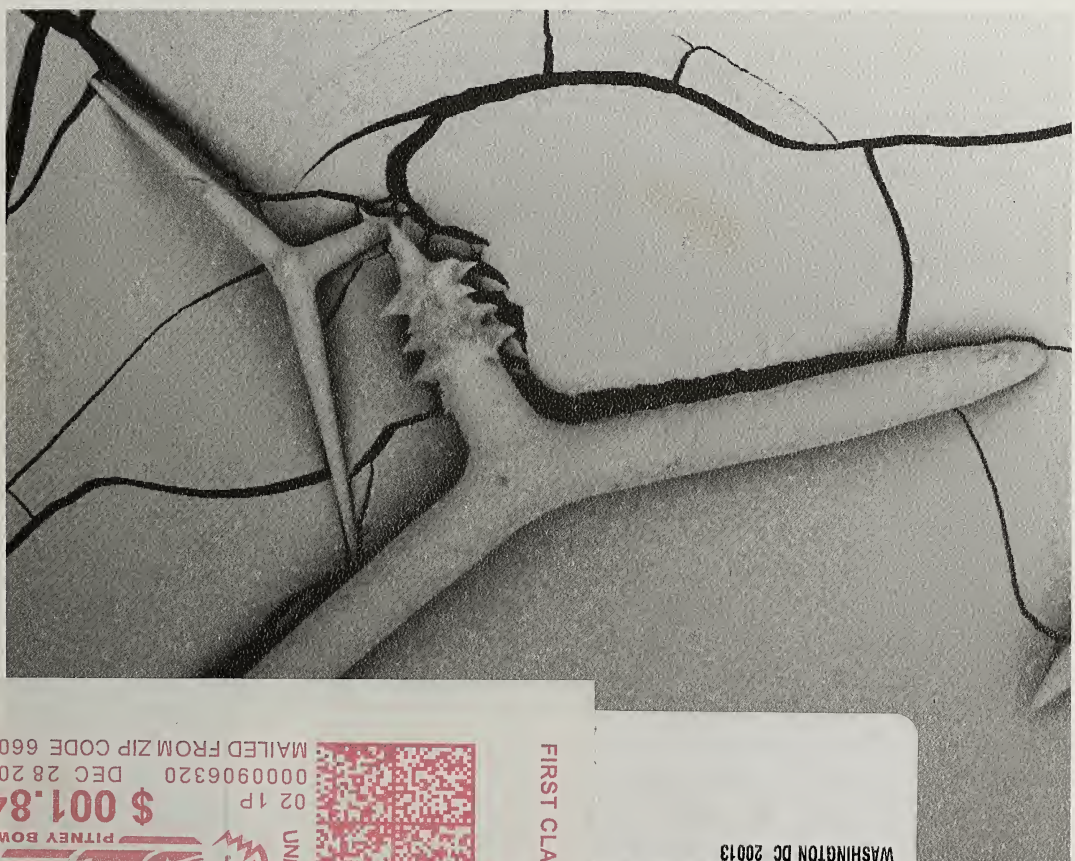

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Mortality of Native and Non-native Fishes during Artificial Breaching of Coastal Lagoons in Southern and Central California

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Abstract.—Fishes of California coastal streams and associated coastal lagoons have adapted to the Mediterranean-style rainfall cycle. Winter rains open the lagoons to the ocean; subsequent lack of rain and seasonal changes in beach dynamics typically closes them for much of the year. Dry and wet season artificial breaching or opening of barrier sand berms has been suspected to disrupt fish populations and lead to mortality of many aquatic organisms including federally endangered species. Such breaches have been rarely observed and then only after at least a few days or more have passed. Artificial breachings of three lagoons have been observed during or within a few hours after breaching and provide documentation of extensive disruption and mortality of aquatic organisms. These observations, Aliso Creek, Orange County (1975), Santa Clara River, Ventura County (2010), and Corcoran Lagoon, Santa Cruz County (2014-2015), confirmed many changes and effects of these events, including mortality of the federally endangered northern and southern tidewater gobies and southern steelhead. Despite the many ostensibly beneficial and non-faunal related reasons for breaching, our observations confirm such actions can cause considerable mortality of threatened and endangered species and are probably more severe than natural wet season breachings. Many city, county, as well as state and federal laws provide regulation of lagoon breaching to protect habitat and minimize or mitigate for impact to sensitive species and these need to be maintained and strengthened.

Many small coastal California lagoons at the mouths of streams and rivers remain nearly or completely closed to the ocean for most of the dry season (~April to November), the typical pattern of Californian and Mediterranean climate-influenced coastal lagoons (Warme et al. 1977; Kjerfve 1994; Woodroffe 2002; Fong and Kennison 2010). The closed condition supports a small but distinctive native estuarine and brackish water aquatic fauna and flora rapidly disappearing due to human modifications to these habitats. Anecdotal observations of artificial breaching of these lagoons have suggested such events adversely affect populations of fishes and other aquatic organisms. Opportunities to observe and document the effects of three such breaching provides some qualitative and quantitative assessments of the effects of these events on both native and non-native fishes and other aquatic organisms.

The sites observed were: Aliso Creek, Orange County, where the southern tidewater goby, *Eucyclogobius kristinae,* was extensively studied [Goldberg 1977; Swift et al. 1989 as *E. newberryi* (Swift et al 2016)]; the mouth of the Santa Clara River, Ventura County,

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Fig. 1. a) Aliso Creek Lagoon, closed to the ocean photo, 2 December 1973 (Swift et al. 1989); b) Trench being dug at mouth of Aliso Creek Lagoon, 2 December 1973; c) Recently drained lagoon from upstream end, 2 December 1973, d) Surf naturally rebuilding barrier berm at Aliso Creek Lagoon, 2 December 1973. Photos by C.C. Swift.

a site extensively studied due to the presence of endangered species and water quality concerns about municipal and agricultural wastewater[1]; and Corcoran Lagoon (Rodeo Gulch), Santa Cruz County, with a much smaller freshwater drainage upstream than the former two. Breaching of the lagoons was observed directly at Aliso Creek and within hours before and/or after breaching at the Santa Clara River and Corcoran Lagoon.

Materials and Methods

Site descriptions

Aliso creek: On 2 December 1973 this long, narrow lagoon (Fig. 1a) was about 0.75 ha, and bordered by a narrow fringe of marsh vegetation between the open water and riprap reinforcing much of the borders. The lagoon was up to 1.5 m deep, 20-25 m wide and about 400 m long with a sandy bottom and a narrow 1-5 m fringe of marsh vegetation near shore. The water level was relatively high, within 30-40 cm vertically from the top of the barrier sand berm (Fig. 1a) and 1-1.5 m above the mean high tide. Low tide was 0.82 m (2.7 ft) at 08:33 and the high tide was only slightly higher at 1.09 m (3.6 ft) at 13:28. The breach started with a hand-excavated trench (Fig. 1b) at 10:00-12:00 hrs and in one to two hours reduced the lagoon by 80-85% with the remaining standing water centered on the

[1] https://www.cityofventura.ca.gov/1248/ArchiveSanta-Clara-River-Estuary-Special.

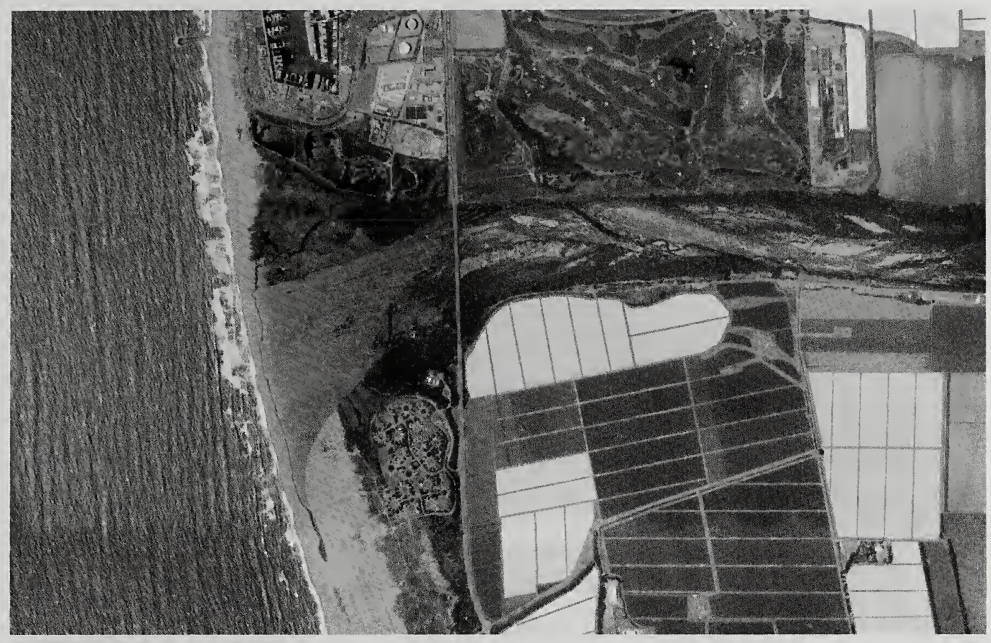

Fig. 2. Aerial view of the Santa Clara River lagoon; Harbor Boulevard bridge runs north-south, about 0.8 km upstream from the ocean.

Hwy 1 bridge (Fig. 1c). The barrier berm was partly rebuilt by the surf in about two hours (Fig. 1d) and the lagoon began to enlarge. The inflow of Aliso Creek (≤ 56 l/sec [2 cfs]) continued to flow over the upper half or so of the newly exposed sandy lagoon bottom. From the upstream to downstream ends the temperature and salinity went from 8.5-9.5°C and 4.8-7.2‰, respectively. No further physical observations were made but the lagoon was relatively high again by early June 1974 (Swift et al. 1989).

Santa Clara river: On 16 September 2010 after months of closure the lagoon level stood a meter or so above high tide behind the sand berm and gradually shallowed upstream to about 600 m above the Harbor Boulevard Bridge. The surface area was about 45 ha (Fig. 2). The lagoon was 700 m to 900 m wide along the beach with a narrow 0.5 km extension to the south. Upstream the lagoon narrowed, increasingly confined by artificial levees. The substrate was over 90% fine to coarse sand with small areas of gravel near the river channel and muddier substrates in some marginal areas. Most depths were ≤1.5 m with extensive marginal emergent aquatic vegetation widest toward the mouth at the beach and riparian forest near and above the Harbor Avenue Bridge. Marginal vegetation was bulrush (*Schoenoplectus* sp. or *Scirpus* sp.), cattails (*Typha* sp.), with willows (*Salix* sp.), and cottonwoods (*Populus fremontii*) beyond on emergent shores. The sandy seaward shore of the lagoon lacked vegetation.

The lagoon was high late the previous afternoon (J. Mann, pers. comm., 17 September 2010) and opened and drained during the night before the survey (Fig. 3a). Earlier on Tuesday, 14 September 2010, C. Spahr and J. Wong, separately observed a trench approximately 1.25 m wide, 3 m long, and 1 m deep between the wetted edge of the lagoon and the upper extent of high tide. After the breach, the river flowed about 283 l/sec (10 cfs) meandering west southwest along the north side and the wastewater outflow channel

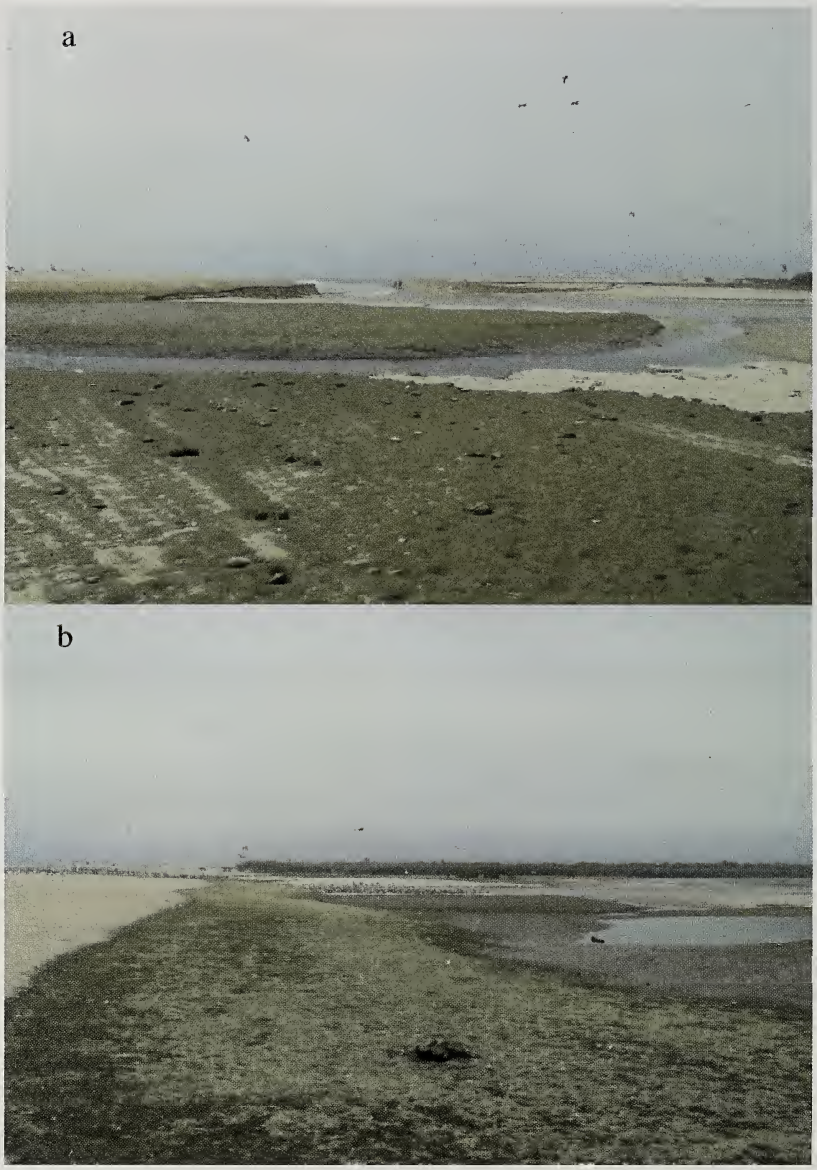

Fig. 3. a) View of lower Santa Clara River lagoon on the morning of observations, 17 September 2010, illustrating the shallow, formerly submerged sand flats with two men standing in the breach in the barrier sand berm for scale. Photo by C. Dellith. b) South side of drained Santa Clara River lagoon with small isolated ponds and seepage from the sand into the remnant watered area. Photo by Chris Dellith, 17 September 2010.

(about 275 l/sec or 9.7 cfs) from the north ran southwest joining the river channel about 150 m upstream of the breach. Less flow emanated from a residual channel ($\leq$ 15 l/sec or $\leq$ 0.5 cfs) from the south side of the lower lagoon to near the breach (Fig. 3b, background). The low tide was 0.148 m (+0.37 ft) at 01:06 and high tide was only 1.24 m (4.1 ft) at 07:51 the morning of the breach and low again at 0.82 m (2.7 ft) at 12:51. The lagoon was

Fig. 4. a) Full Corcoran lagoon before breach, 19 December 2015; b) Trench dug on beach at seaward end of Corcoran lagoon. 19 December 2015; c) Drained Corcoran lagoon about the same area as shown when lagoon full in Fig. 4a, 11 February 2014; d) Moribund northern tidewater gobies on substrate of Corcoran Lagoon coated with sand from struggling on the surface after sudden lowering of the lagoon. 11 February 2014. Photos by K. Kittleson.

reduced to about 10% of its aerial extent. A residual ponded area just inside the gap in the beach was roughly circular, about 50 m in diameter, and had been 3-4 m deep judging by the empty lagoon border (Fig. 3a). The remaining drained area was exposed moist sand with seepage and two remnant pools on the south side. The large gap in the barrier sand berm remained by 16:00 with a strong outflowing current. Water temperatures ranged from 17-20°C. and salinities from 1.0-2.5‰ measured at three locations: at Harbor Boulevard, just inside the break in the beach berm, and to the north in the wastewater outflow. The narrow range of water quality measurements over widely spaced sites indicates the lagoon was well mixed and very similar in temperature and salinity in the areas less than 2 m deep. The deep pool near the ocean may have been more saline at depth. Some wave surge carried into the lower lagoon during the first half of the day within 150 m of the breach. The water throughout the lagoon was yellowish to greenish, visibility limited to about 40-50 cm. At Harbor Boulevard Bridge, the water coming down the river was clearer but roiled by fish activity. The lagoon had not appreciably refilled by approximately 16:30 when the survey ended.

Corcoran lagoon: On 10-11 February 2014 the lagoon was high and rising during rains and flooded the coastal road near the beach, East Cliff Drive (Fig. 4a), and threatened Radio Station facilities on piers in the lagoon. The lagoon covered about 7-8 ha and was

up to about 2.5 m deep under the East Cliff Drive bridge at the mouth of the lagoon. A trench was observed on the beach on the afternoon of 10 February 2014 but was not deep enough to initiate flow from the lagoon to the ocean. The lagoon breached the morning of 11 February 2014 reducing the lagoon to about 3 ha and a depth of about 30 cm at the bridge and it remained very low through 12 February 2014. The high tide was 1.52 m (5.0 ft) at 01:40, a low of 0.43 m (1.4 ft) at 07:45, and another high of 1.13 m (3.7 ft) at 13:44.

Preceding a 21 December 2015 breaching event East Cliff Drive again was flooded by water about 25 cm deep by 14 December 2015, was still high on 19 December 2015, and at mid-day a small trench had a small outgoing flow (Fig. 4b). This trench was filled in mid-afternoon. On the 20 December 2015 the lagoon was still high, more than 2 m deep. By 09:00 on 21 December 2015 the lagoon had breached and drained (Fig. 4c). The wetted surface area was reduced by 80-90%. The low tide late (19:29) on the 20 December 2015 was 0.06 m (0.2 ft) and on the 21 December 2015 a high of 1.28 m (4.2 ft) at 03:26, low of 1.04 m (3.4 ft) at 08:23, and high again of 1.28 m (4.2) at 12:56.

The events at Aliso Creek and Corcoran Lagoon were observed visually over most of each lagoon area with some dead specimens taken by hand and a few seine hauls with a 4.6 m × 1.8 m (15 × 6 ft) 3.2 mm ($1/8^{th}$ in) mesh seine at Aliso Creek. At Santa Clara River the lagoon was sampled with a seine (3.2 × 1.2 m, 3 mm mesh) at 28 stations on both sides of the remnant channels and pools from 50 meters above Harbor Boulevard to just inside the beach. Visual observations were conducted over 50-60% of the dewatered lagoon. Water quality was taken with a YSI water quality meter in the Santa Clara and with hand held thermometers and refractometers at Aliso Creek. Wastewater discharge was obtained by the City of Ventura Wastewater data and the river and small tributary flows were estimated on site. Tide levels were taken from National Oceanographic and Oceanic Administration (NOAA) websites. Fish numbers were often estimated and released to avoid additional stress. Voucher specimens of some moribund tidewater gobies and steelhead, and some other fish were kept for further study and deposited in the Natural History Museum of Los Angeles County and with the National Marine Fisheries Service (steelhead) and U.S. Fish and Wildlife Service (tidewater gobies).

Results

Aliso creek: Ten to twenty gulls were actively feeding on the newly exposed flats of the drained lagoon presumably on southern tidewater gobies and mosquitofish the only common fishes in the lagoon. Seining in the remnant lagoon took a few hundred southern tidewater gobies but only about 7-10 mosquitofish. Seine hauls took the gobies almost exclusively in the upper half of the lagoon, both in the full lagoon and after breaching in the much smaller residual lagoon that remained.

Santa Clara river: Live native fish species captured in seine hauls included northern tidewater goby (~1855), staghorn sculpin (*Leptocottus armatus*) (2), threespine stickleback (*Gasterosteus aculeatus*) (10 adult), and California killifish (*Fundulus parvipinnis*) (1 adult). Live non-native fishes captured were mosquitofish (*Gambusia affinis*) (51), arroyo chub (*Gila orcutti*) (15), fathead minnow (*Pimephales promelas*) (102), Mississippi silverside (*Menidia audens*) (15), carp, *Cyprinus carpio* (97), prickly sculpin (*Cottus asper*) (63), and green sunfish (*Lepomis cyanellus*) (114). In addition, one African clawed frog larvae (tadpole) (*Xenopus laevis*), and approximately 10 red swamp crayfish (*Procambarus clarki*), were taken.

Additional native fishes observed moribund included at least 2000 northern tidewater gobies (dead on the exposed lagoon bottom, approximately 3-5/m^2 in many areas), staghorn Sculpin (4-5 dead on sand bar), striped mullet (*Mugil cephalus*) (1), and southern steelhead (7 dead in the flowing river channel from about 100 m above to 400 m below Harbor Boulevard Bridge). Moribund non-native species observed included several hundred to a few thousand each of fathead minnows, juvenile green sunfish, and carp. A few hundred each of prickly sculpin, suckers (*Catostomus santaanae, C. fumeiventris,* and their hybrids), mosquitofish, and one large black bullhead (*Ameiurus melas*), were observed mostly in the upper half of the lagoon. Ten to 15 dead Mississippi Silversides were seen also. At least 200 or more adult carp were observed in the main river channel from above Harbor Boulevard Bridge to within 100 m of the ocean and were acting distressed or expiring in increasing numbers through the day.

Carp, fathead minnows, and northern tidewater gobies were represented by all sizes from small juveniles to large adults. The threespine stickleback and California killifish were all adults from an isolated backwater pool on the lagoon bottom south of the breach to the ocean. The staghorn sculpin were captured in the lower one third of the lagoon and were large juveniles. The mosquitofish were captured mostly in the upper half of the lagoon and wastewater channel. The Mississippi silversides were adults widely scattered in the lagoon and usually freshly dead. The green sunfish were captured throughout the lagoon and were overwhelmingly juveniles less than approximately 70 mm.

About half the expanse of bare sand and mud was carefully examined and dead northern tidewater gobies, green sunfish, and fathead minnows were stranded and coated with sand. Far fewer suckers, prickly sculpin, or carp were stranded probably because they were more oriented to the stream channels where flow prevailed and not widely distributed in the lagoon. Most of them were in the upper half of the river channel and showing signs of stress gasping at the water surface or lying unresponsively at the water's edge; probably due to low oxygen conditions that likely lead to the mortality of the southern steelhead.

The outer ocean beach was examined for ~0.80 km north of the breach during the early afternoon. In the fresh wrack line along the upper reach of the waves, freshly dead northern tidewater gobies, juvenile green sunfish, fathead minnows, and a single striped mullet were noted. These small species (excluding the mullet) were estimated 5-10 indiv/m of beach (thus 4000-8000 total fish). Some of the tidewater gobies were alive and returned to the water but many were dead. The green sunfish and fathead minnow probably died due to intolerance of high salinity.

Live juvenile and adult African clawed frogs were abundant and concentrated in the pooled deeper water just inside the breach to the ocean. Many were rising to the surface as if feeding but probably air breathing. Clearly hundreds, if not a few thousand, were present. Seaward and north of the breach at least 20 struggled out of the ocean surf to be preyed upon by Heermann's gulls (*Larus heermannii*), and beach visitors related witnessing this all day before our survey at 13:30. At least 15 dead clawed frogs were on the dune sand apparently expiring while attempting to cross the dry sand directly back to the lagoon.

Corcoran lagoon: In the afternoon of 11 February 2014 about 1000 northern tidewater gobies were rescued by being placed back in the remaining water. Between 1000 and 2000 were dead on the sand, similar to those seen at the Santa Clara (Fig. 4d). A small number of threespine stickleback ($\leq$10), and at least one arrow goby, *Clevelandia ios*, died also. On the following day at about 13:00 hrs most of the dead gobies were gone and a few live ones were observed in shallow water in the lagoon still much reduced size.

After the draining that began on 21 December 2015 and continued on the 22 December 2015, 21 dead northern tidewater gobies were found on the mudflat upstream of the East Cliff Drive bridge and 10 others were still alive and rescued. About 30 dead threespine stickleback and one non-native tench, *Tinca tinca*, were also noted and 20 or more snowy egrets, *Egretta thula*, were actively feeding around the shallow remaining pools.

Discussion

Mild to extensive mortality of many kinds of both native and exotic fish species occurred during the dewatering events observed here. Most conspicuous and numerous were the native northern and southern tidewater gobies in the Santa Clara and Corcoran lagoons. Fathead minnows and green sunfish were also abundant among the moribund fish in the Santa Clara. At Aliso and Corcoran lagoons few other fishes were impacted, namely mosquitofish in the former and threespine stickleback in the latter. In addition to stranding, in the Santa Clara many fish (except tidewater gobies) and clawed frogs seemed stressed and unresponsive, probably due to the low oxygen. Hundreds of the aquatic invasive African clawed frogs known to prey on tidewater gobies (Lafferty and Page 1997) were also concentrated. Such concentration of predators can lead to extensive predation on smaller prey species adding to mortality.

Despite this mortality the species typically survive these events but may become more vulnerable to other impacts. Several extirpations of northern and southern tidewater gobies came after exceptionally high winter flows that apparently flushed the whole local population out of systems already channelized such that lateral marsh refuges were absent (Swift et al. 1989; 2018: USFWS 2005). The more extreme artificial breachings are more likely to dewater the marginal refuge areas at seasons when inflows are minimal or non-existent to rewater them fast enough to allow fish to survive.

Seven freshly moribund steelhead were found in the Santa Clara and no live individuals were seen. In the earlier spring and summer biologists with the United Water Conservation District transferred 64 smolts to the lagoon from the Freeman Diversion (16 km upstream); 34 when the lagoon was still open and 30 after it had closed (S. Howard, pers. comm., 22 September 2010). Additional smolts may have passed the diversion during high spring passage flows. Some preliminary studies indicate that smolts released in an open Santa Clara River lagoon leave for the ocean in a few days[2] (Kelley 2008). The fish found may have been among those transferred after the lagoon had closed. The relatively large size (227-310 mm SL; 267-365 mm TL) and robust condition of these fish indicated they were doing relatively well in the lagoon or river near the lagoon and that adequate conditions existed for them in at least part of the local habitat. The river was intermittently dry upstream and they were not recent arrivals to the lagoon area.

In contrast to other fish species noted, northern and southern tidewater gobies remaining in the Santa Clara and Aliso, respectively, appeared in relatively good condition. They were lively and not observed coming to the surface to take advantage of aerial oxygen although they have been observed to do so elsewhere (C. Swift, pers. Obs.). They seem to be able to survive relatively low oxygen levels as long as they remain in the water. The many dead tidewater gobies succumbed to stranding in the dewatered areas of the lagoon.

[2] Kelley, E. 2008. Steelhead trout smolt survival: Santa Clara and Santa Ynez estuaries. Report for California Department of Fish and Game Fisheries Restoration Program, University of California, Santa Barbara, Santa Barbara, CA. 61 pp.

Possibly breeding burrows became uninhabitable with the withdrawal of water also causing the loss of egg clutches still unhatched. Some of the northern tidewater goby found dead on the outer ocean beach were probably intolerant of the churning surf, high salinity or both. Southern tidewater gobies can tolerate marine salinities but only with time for acclimation (Swift et al. 1989).

Tidewater gobies are often one of the most abundant native species in California coastal lagoons (Swift et al. 1989; 2018; Swenson 1999; USFWS 2005). During the Santa Clara event the other native species were rare, namely partially-armored threespine stickleback, California killifish, striped mullet, and staghorn sculpin. Their rarity was surprising since the lowered lagoon was very accessible to sampling during this survey and the fish had just been concentrated. Possibly they have a greater tendency to be carried out or actively leave the lagoon during such events. During previous lagoon surveys small juveniles of topsmelt (*Atherinops affinis*) and starry flounder (*Platichthys stellatus*) have been captured. A few other native estuarine species potentially present but not detected during this survey are diamond turbot (*Pleuronichthyes guttulatus*), shiner perch (*Cymatogaster aggregata*), yellowfin croaker (*Umbrina roncador*), arrow goby (*Clevelandia ios*), longjaw mudsucker (*Gillichthys miribalis*), and California halibut (*Paralichthys californicus*). They are usually rare in closed estuarine systems and could have gone undetected, or been carried out of the lagoon.

In the Santa Clara non-native arroyo chub and Mississippi silversides were also rare, while the green sunfish and fathead minnows were abundant. Mosquitofish were moderately abundant and tended to occur in the upper half to one third of the lagoon as did the suckers and prickly sculpin. Mississippi silversides, introduced in northern California in the 1960s, came down the California aqueduct into coastal southern California by the early 1990s, becoming widespread in freshwater and estuarine habitats of southern California (Swift et al. 2015). Ecologically similar to topsmelt, interactions between the two species are not well understood but the Mississippi Silversides appear to becoming more common while topsmelt numbers decline in the Santa Clara lagoon. Topsmelt juveniles provide food for the federally endangered California least tern and Mississippi silversides may fill this role. California least tern are known to forage in the Santa Clara River estuary; however, they are a migratory species and had likely departed for their wintering grounds by the time the breach had occurred. Mississippi silversides are smaller (≤100 mm SL) than topsmelt (≤200 mm SL in estuaries) but reach sizes that are targeted by California least terns. Mississippi silversides may not be large enough to be optimal for the larger species like Forster's tern (*Sterna forsteri*), Caspian tern (*Sterna caspia*), and elegant tern (*Sterna elegans*), that also breed and forage along the southern California coastline.

At all three sites artificially dug trenches facilitated the draining of lagoons and coincided with lower than average low tides and weak high tides allowing at or near maximum draining of lagoons over a few hours or less. The digging of the trench and emptying of the lagoon was directly observed at Aliso Creek. The trenches observed shortly before the breaches at the Santa Clara and Corcoran likely precipitated those. Once water begins to flow outward it rapidly erodes down through the unconsolidated beach sand emptying the lagoon in an hour or two in the case of Aliso and Corcoran. Natural breaches typically occur during high inflows when lagoons are large and the outflows exit over shallower sills in the beach displaced laterally along the coast muting the extent of draining. The lagoons become much shallower but often do not diminish appreciably in wetted surface area. At many sites today, coastal lagoons are constrained from expanding laterally along the coast forcing breaches more directly across the barrier beach in line with their tributary

channel. Thus, even natural breaches can become more extreme in the extent of dewatering of lagoon habitat.

Closure is often artificially disrupted in California coastal lagoons for benefits considered desirable for a variety of local conditions. Some in the surfing community believe the new nearshore sediment profile produced by the rush of outgoing water improves the break of the surf and thus the surfing experience. Rising lagoon waters threaten to flood nearby, low-lying structures or land so breaching lowers the water level. In the fall steelhead are attracted to and accumulate in the ocean offshore of lagoons. Anglers and fishery managers may open lagoons to facilitate entrance of these fish. At the mouth of the Santa Clara River and several other coastal lagoons California State Park facilities or private land holdings are within zones often flooded by high lagoon levels. Opening the lagoons allows continuing use of these facilities. Lagoons may get warm and choked with green algae in summer and fall and perceived as a visual or olfactory nuisance to be drained away to the ocean. However, in some cases lagoon pollution, i.e. high coliform bacterial levels, will be spread along swimming beaches by artificial breaching. This creates conflict between needs to keep beaches healthy and lowering lagoon levels.

The outflow of the City of Ventura Wastewater treatment plant just north of the lagoon also contributed substantially to the water volume in the Santa Clara River lagoon and a small volume of wastewater flow was in Aliso Creek as well. These inputs may keep the lagoons larger than would otherwise be the case but may also substitute for water no longer reaching the lagoons due to upstream diversions and extractions for municipal, agricultural, and recreational use. Additional water originating from the Owens River (Los Angeles Aqueduct) and the California Aqueduct intermittently enters the Santa Clara drainage upstream also complicating any exact assessment of how today's lagoons correspond to a "natural" state. Given large historical runs of Southern Steelhead in the system (Boughton et al. 2006, 2007) known elsewhere to depend considerably on coastal lagoon systems for recruitment (Satterthwaite et al. 2012) lagoon development should have been substantial and reliable in the past. Aliso Creek lagoon was larger and supported a large population of tidewater goby and southwestern pond turtle, *Actinemys marmorata*, early in the first decade of the 20th century before its narrowing for the development of U. S. Hwy 1 and State Park parking lot (Fig. 1a, Metz 1912).

Many management proposals for restoration of lagoons favor opening them to the ocean to improve circulation and water quality and increase biodiversity. The increase in biodiversity comes at the expense of the species adapted to the original brackish non-tidal habitat, some of which are now threatened and endangered species. Extreme modification has occurred historically to many larger lagoons that have been transformed into marinas and harbors maintained by artificial jetties at their mouths and requiring periodic dredging to prevent the natural tendency for the openings to close. The fish communities of these modified systems have been extensively studied (Allen et al. 2006). Many smaller systems remain in somewhat natural condition, such as the Santa Clara River lagoon, and should be managed to mimic natural hydrological and sedimentary cycles that benefit the native species. Awareness of the importance of intact and natural seasonal cycles to the health and success of two high profile fish species, namely tidewater goby (Swift et al. 1989; Swenson 1999; U.SFWS 2005; Swift et al. 2018) and southern and south central California steelhead (Boughton et al. 2006, 2007; NMFS 2011; Satterthwaite et al. 2012), has developed into wider appreciation for the importance of preserving the dynamic original geological and hydrological cycle of these habitats for conservation and recovery of these declining species.

Our observations clearly document some of adverse effects of artificial breaching of coastal lagoons in California. If accomplished repeatedly in a given dry season, the effects will be magnified. It is clear from the historical record and analyses of hydrological and sedimentary processes dry season breaches of lagoons were infrequent or absent under natural conditions in many systems[3]. The breaches at the Santa Clara River often only occur once or twice in September of each year and as noted here often initiated artificially. If natural dry season breaches took place, they would be expected to be random in relation to the tide cycle and would often cause much less draining. A smaller breach allows only a muted tide to develop before the berm closes again. From spring through summer, the surf from the southwest and south builds up the sand berms (Bascom 1980) and they get progressively wider through late summer and fall, becoming less likely to breach. The wave action also deflects the lagoon opening along the beach and the lowest point in the berm often is found at the extreme downcoast end of the lagoon (Fig. 1a). This means overtopping by high waves rarely if ever results in dramatic lowering of the lagoon. Today the coastal beach sediment supply is reduced by dams upstream and the lower watercourses are channelized more or less straight to the beach. Less sediment comes down to build the beach and the force of winter flows impinge more directly and forcefully against the barrier berm. The lagoons cannot extend as widely along the coast behind the dunes as originally and may breach more now because of these factors. In any case natural breaching is less frequent under natural or historical conditions and restoration efforts should mimic these conditions for the associated habitats, fauna, and flora to maintain themselves[3].

Acknowledgements

Observations at Aliso Creek were made with Scott Stockton, Carolyn Maslow, and Theodore Stein. At the Santa Clara River Swift and Mulder were supported by the City of Ventura Wastewater Division; Carly Sphar and Jason Wong provided some observations on trenching activities and lagoon conditions. James Mann, Wendy Willis, Alan Calvin, and Brianna Jones of Aquatic BioAssay and Consulting provided field assistance and water quality data for Santa Clara River. Steve Howard, United Water District, provided information on steelhead transfers to the lagoon. Bill Graff, Nathan Salazar, Keith Angell, provided observations on Corcoran Lagoon. The findings and conclusions in this article are those of the authors and do not necessarily represent the view of the U.S. Fish and Wildlife Service, Cardno ENTRIX (now Cardno), Inc., ISI International or City of Santa Cruz.

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California Records of the Oarfish, *Regalecus russelii* (Cuvier, 1816) (Actinopterygii: Regalecidae)

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Recent oarfish strandings in California have generated enormous interest. Oarfishes are iconic and have been feared as 'sea monsters or serpents' in the past and 'harbingers of earthquakes' more recently. The amount of media coverage and subsequent misconceptions has motivated us to document the California stranding records as best we can based on the most reliable information.

Most accounts over the last century have regarded *Regalecus* as monotypic, as *R. glesne* (Heemstra 1986; Olney 2002; Horn et al. 2006; Nelson 2006; Page et al. 2013; Kells et al. 2016). Historically, and more recently, a second species, *R. russelii* or with a modified species spelling as *russellii* [as *russelii* (Cuvier 1816 (ex Shaw)) by Eschmeyer et al. 2017], has been recognized (Jordan 1902, 1907; Jordan and Starks 1907; Fujii 1984; Hayashi 2002; Roberts 2012, 2016; Angulo and López-Sánchez 2017). Both species have circumglobal, but not entirely overlapping, distributions. However, only *R. russelii* has been found, so far, in the northeastern Pacific, including Mexico, Costa Rica, and central and southern California.

Morphologically, *Regalecus russelii* is characterized by 3-6 rays in the first dorsal crest and a single ray in the second dorsal crest, not connected with a membrane to the other. *Regalecus glesne* has 6-8 rays in the first crest and 5-11 rays in the second crest (Roberts 2012). The total number of dorsal rays, vertebrae and gill rakers are also diagnostic. Mitochondrial DNA sequences indicate distinct separation between these species (Roberts 2012).

We have attempted to access all sources of information related to oarfish strandings off California, including newspaper articles, natural history museum records, published accounts, and the files and correspondence of Boyd Walker, John Fitch, Vladimir Walters, and other ichthyologists interested in early oarfish strandings. We have examined all California specimens at The Natural History Museum of Los Angeles County (LACM), Santa Barbara Museum of Natural History (SBMNH), Scripps Institution of Oceanography (SIO), and University of California Los Angeles (UCLA, now transferred to SIO). We have also searched VertNet (http://www.vertnet.org) and iDigBio (https://www.idigbio.org/) records.

Length measurements are total lengths. In eight cases we feel the original measurements were by metric tape (numbers 3, 5, 7, 9, 10, 12, 13 and 18), one by John Fitch, two by LACM staff, one by scientists at the USC Wrigley Marine Science Center at Santa Catalina Island, one at the Catalina Island Marine Institute, one by researchers at California State University Fullerton, and two San Diego County specimens by researchers at Scripps Institute of Oceanography and the Southwest Fisheries Science Center, La Jolla.

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California records.—We have verified a total of nineteen oarfish strandings and sightings along the California coast, since 1901, all from southern California with the exception of one sighting slightly north of the Point Conception boundary, plus several unverified and extralimital records.

1) 22 February 1901. The first recorded oarfish (Fig. 1A) from California was found "about one mile up the coast" from Newport Beach (Jordan 1902, Jordan 1907, Jordan and Starks 1907, Fitch 1951, Los Angeles Times 24 Feb 1901, Los Angeles Herald 26 Feb. 1901). It was 6.71 m (22 ft) long and weighed an estimated 500-600 lbs. (Jordan and Starks 1907). Jordan (1907) also mentions Santa Catalina Island where "during the past few years I have seen one oarfish (*Regalecus russelli*) alive, while another was brought to me dead," indicating that there may have been a few more unconfirmed sightings at Catalina Island during this time.

2) 29 March 1950. A 3.20 m (10.5 ft) oarfish was sighted by Thomas DeGarmo "swimming feebly just off a point of rocks" at Cabrillo Museum, near San Pedro (Fig. 1B) (Fitch 1951, Fitch and Lavenberg 1968). The head was badly damaged, a few feet of the tail were missing and the weight was estimated at 113.4 kg (250 lbs). A cast was made and the specimen was donated to Scripps Institution of Oceanography and given the catalog number SIO 50-115. Tom Deméré (San Diego Natural History Museum) discovered that the SDNHM model has a label indicating it is a "cast made from a fish taken near San Pedro in 1950." The number of rays in the crest of the model match *R. glesne* and may been incorrectly added due to the damaged condition of the specimen's head.

3) 7 February 1958. A 1.76 m (5.8 ft) oarfish was picked up by Linc Foster at 11 AM on a beach in Santa Monica Bay, just south of Topanga Canyon (Fig. 1C) (From John Fitch correspondence to Vladimir Walters, 25 February 1958). The specimen was found on the beach while it was still barely alive. The body broke in half as it was lifted. It was turned over to Dr. Kenneth Norris at Marineland of the Pacific and the above data recorded in their field notebook under MLP58-2. An additional maximum of 110 mm of the tail was estimated to be missing by Fitch, possibly making it about 1.87 m. in length. Subsequently, it was cataloged at the University of California Los Angeles (W58-267) and now resides at the Scripps Institution of Oceanography (D. Buth, UCLA, per. com. 2013). The SIO 15-113 label has 1,750 mm written as the length. Fitch counted six rays in the dorsal crests (nuchal pendants).

4) 24 September 1963. A 4.12 m (13.5 ft) fish was stranded 3.2 km (2 mi) west of Malibu pier (Los Angeles Times, 27 Sept. 1963, Roberts 2012). Vladimir Walters and Boyd Walker (UCLA) estimated that about 1.5 m (5 ft) of the tail were missing, making the complete fish about 5.64 m (18.5 ft) long. A subsequent Los Angeles Times article (1 October 1963) stated " ...an 18½-ft oar fish, will be on display outside the Life Science Building at UCLA." Fitch and Lavenberg (1968) mention a "19-footer from near Topanga Canyon." We assume it is the same fish. They said it was preserved in the fish collections at the Los Angeles County Museum of Natural History. An inventory of wooden tanks at the Museum's Marine Mammal Warehouse listed an uncataloged "Oarfish (dried formalin)" in WT-17. This specimen was discarded in 2006. No picture is available.

5) 25 January 1970. A 4.39 m (14.4 ft) specimen (Fig. 1D) was found dying in the surf by Foster and Francis Phelps, 2.4 km (1.5 mi) northwest of the Ventura-Los Angeles County line. Roberts (2012) has the locality as Malibu, Leo Carrillo State Beach, 4.1 m, stranded. It originally went to Marineland of the Pacific and then was deposited at the Natural History Museum of Los Angeles County (LACM 31697-1) about a year later. Camm Swift

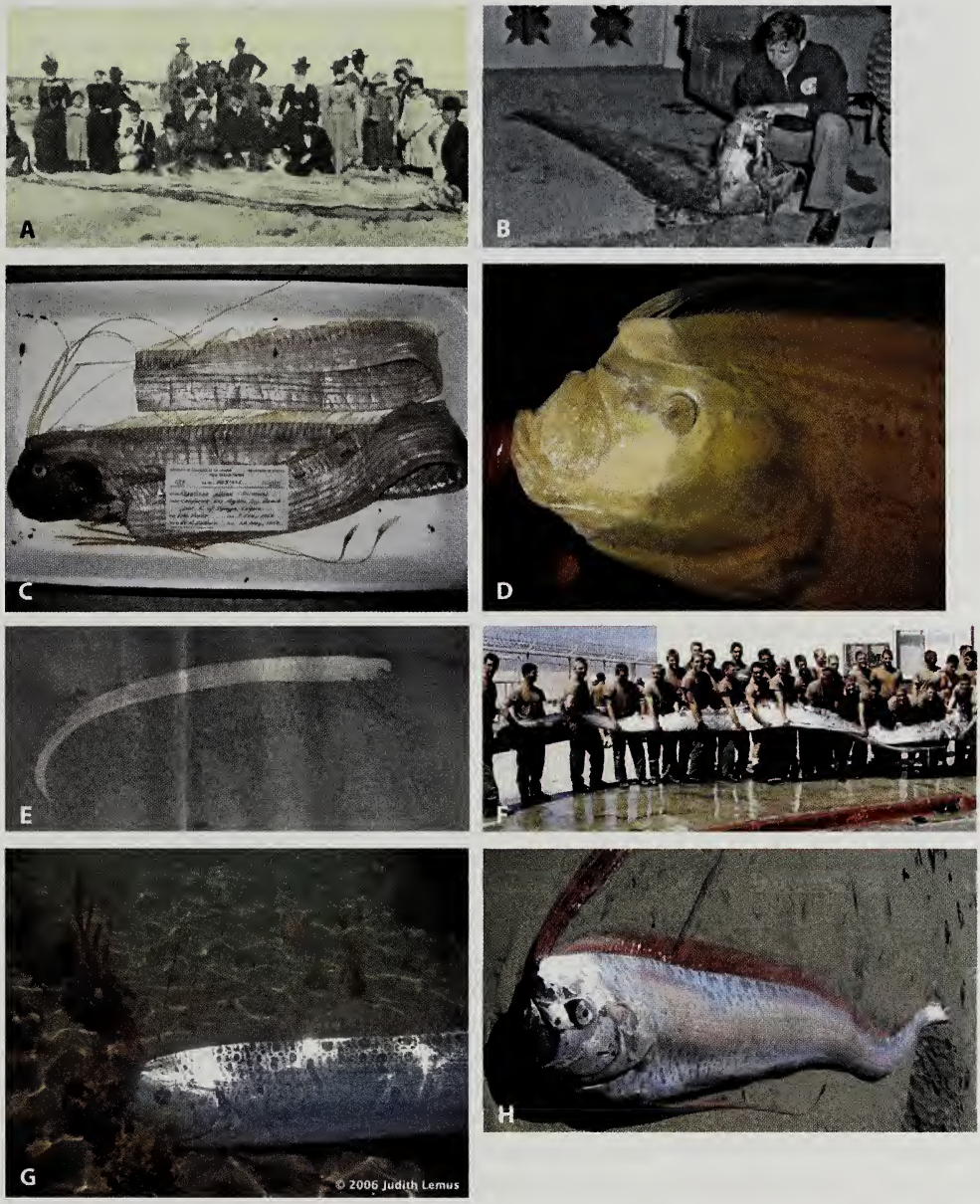

Fig. 1. **A** Newport Beach oarfish, February, 1901, from Jordan (1907). **B** Cabrillo Museum oarfish and John Olguin, 1950, courtesy of J. Passarelli. **C** Santa Monica Bay oarfish, 1958, SIO 15-113, image by RF. **D** County Line specimen (LACM 31697-1) by E. Hernandez. **E** County Line oarfish number two, 20 July 1992, by Steve Wallace. **F** Coronado oarfish, 1996, by W. Leo Smith. **G** Santa Catalina Is. oarfish, 2006, by Judy Lemus. **H** Malibu oarfish, 2010, by Darrell Rae.

re-measured the specimen as 4.39 m (14.4 ft.). Part of the tail was missing, assumed to be bitten off. The specimen was on display in the Foyer at the LACM for many years until being replaced by the 2006 Catalina fish in 2007. The specimen was cast and a model made for display in the Marine Hall (Emboden 1974), with a relatively large, fan-shaped,

dorsally-directed tail fin added (inaccurate because it resembles the upper lobe of the caudal fin of a ribbonfish, Trachipteridae). The model is on display in the Discovery Hall on the second floor. An otolith in the John Fitch Otolith Collection is labeled "Jan 1970 ±18 ft." We think it is likely from this specimen. Fitch was probably estimating how long the fish was if the tail was intact.

6) 12 July 1992. An oarfish was observed "undulating in the surf" and photographed by Steve Wallace (Fig. 1E) on the beach, near Malibu at Ventura County line. (Bill Beebe, Los Angeles Times, 24 July 1992). Beebe stated the sighting took place two Sundays prior to his article. Records at LACM had date as July 20. "It looked like a sea serpent about six or eight feet long. It had a head like a dorado (dolphin fish) and shaped like an eel." Wallace indicated that the fish was washed back out to sea while he was there.

7) 19 September 1996. An oarfish estimated as 7.0 to 7.3 m (23 to 24 ft) was found on the beach at Coronado, near the Coronado U.S. Naval Special Warfare Command Center, by Scott Vogt and other U.S. Navy SEALS (Fig. 1F) and reported to the Birch Aquarium at Scripps Institution of Oceanography (The San Diego Union-Tribune 27 Sept. 1996; Smith 1996; Roberts 2012). The specimen was measured and dissected by H.J. Walker, Cindy Klepadlo and Leo Smith of Scripps Institution of Oceanography on Coronado at the Naval Center. They measured it at "just over seven meters" but estimated it to be 23 to 24 feet because the tip of the tail was missing (Smith 1996). SIO field notes have the "estimated" length as 7.3 m. Following examination of the whole fish the head and a portion of the tail were removed and are now accessioned at the Marine Vertebrate Collection (SIO 96-82) along with a DNA tissue sample. Dorsal crests fin rays total 6; gill rakers 13+39 = 52. The Navy buried the remaining parts of the specimen.

8) 26 October 1997. A 5.0 m (16.4 ft) specimen (SIO 97-226) was caught by a commercial fisherman with a gill net off San Diego, ca. 17 mi. W of Point Loma. Tissue analysis confirmed it was *R. russelii* (Roberts 2012). The head and tail were saved. No picture.

9) 16 August 2006. A 4.46 m (14.6 ft) oarfish (Fig. 1G) appeared in Big Fisherman Cove, near the USC Wrigley Marine Science Center, Santa Catalina Island (Museum records; Pete Thomas, Los Angeles Times, 26 Aug 2006). Judy Lemus and many others at the Marine Science Center observed the fish alive, but feeble, in Big Fisherman Cove for about a day until it beached itself. Kevin O'Connor took a video of it swimming underwater (LACM files). Gerry M. Smith and Judy Lemus froze the specimen and contacted the Natural History Museum of Los Angeles County. The specimen was kept frozen at the Museum until 31 May 2007 when a stainless steel tank, ordered specifically for this fish, was ready. The specimen was examined, dissected and cataloged as LACM 56478-1. Tissues (T-000847) were frozen. The specimen was fixed in formalin and then moved to 70% ethanol when put on display in the Foyer of the Museum in 2007. There were two dorsal crests with 5+1 rays, plus 173 rays = 179 total dorsal rays; 5+1+62 dorsal rays to vertical at vent. Gill rakers 14 upper + 37 lower. Tissue was sent to Tyson Roberts at Smithsonian Tropical Research Institute on 4 Dec 2008.

10) 28 November 2010. Darrell Rae observed a 3.28 m (10.8 ft) oarfish swimming a few feet from shore before it washed up at the Malibu Colony, just west of Malibu Lagoon (Fig. 1H) (Malibu Times, Carly Erickson, 1 December 2010; Los Angeles Times, Tony Barbosa, 3 December 2010). Jeff Hall from the California Wildlife Center collected the specimen and it was transferred to the Natural History Museum of Los Angeles County. Tissue was taken (T-001206) and the fish was cataloged as LACM 57292-1. The dorsal

crests numbered 5+1. In 2016 reproductive tissue was sampled by Kristy Forsgren of California State University Fullerton (Forsgren et al. 2017).

11) 7 February 2011. A 4.3 m (14 ft) specimen was stranded at Surf Beach, just south of Ocean Beach County Park, near Lompoc (email to RF from Kristi Birney, Environmental Defense Center, Santa Barbara, CA) (Fig. 2A-B). It was photographed by John Downs in the late afternoon, but not collected; it apparently washed back to sea at high tide that night. It appears there were six rays in the dorsal crests. Surf Beach is ca. 35 km north of Point Conception and ca.13 miles north of Point Arguello. It represents the northernmost record of *Regalecus* in the eastern Pacific.

12) 13 October 2013. Jasmine Santana, of the Catalina Island Marine Institute, saw a dead 5.27 m (17.3 ft) long oarfish (Fig. 2C) lying on the bottom at about 5 m. while snorkeling in Toyon Bay, Santa Catalina Island. She grabbed it by the tail and swam it to shore, estimating it weighed about 181 kg (400 lbs). It was well-publicized by local media (Los Angeles Times, 16 October 2013). Dissection determined that it was probably a male. The stomach was empty. Taylor Sakmar of CIMI contacted the LACM about the specimen. Tissue samples (T-001236 to T-001248), gill samples, dorsal and pectoral fin ray samples, heart, liver, kidney, kidney blood, gonads, tip of tail, and muscle from the abdominal wall were given to the Natural History Museum (LACM 58180-1) via David Work. The gall bladder, parts of the gills, stomach, spleen, part of the intestine, and gastric caecum went to the Ecological Parasitology Lab, University of California, Santa Barbara. They found several types of larval and juvenile parasitic tapeworms and nematodes. Oarfish may act as intermediate hosts for adult parasites of the same taxa found in Shortfin Mako and Sperm Whales (Kuris et al. 2015). Also, an otolith, dorsal ray and pelvic ray were sampled for ageing (Midway and Wagner 2016).

13) 18 October 2013. A 4.45 m (14.6 ft) oarfish was discovered on the beach at Oceanside (33°12′N, 117°23′W), near the harbor breakwater (Fig. 2D). The specimen was analyzed by scientists from the NOAA Southwest Fisheries Science Center, La Jolla. The head was damaged. It was determined to be a female with eggs. Some tissues and parts went to the Scripps Institution of Oceanography, Marine Vertebrate Collection (SIO 13-259). Remaining tissues went to California State University Fullerton, frozen, and later CT-scanned at UCLA; hyperostosic dorsal pterygiophores were present (Paig-Tran et al. 2016).

14) 9 August 2014. Patricia Malone and party photographed an estimated 4.6 m (15 ft) oarfish on Santa Rosa Island, between Skunk Point and Torrey Pines, on Bechers Bay (approx. 33°59′N, 120°0′W)(Fig. 2E-F). She said it was freshly dead with little decomposition but the eyes were missing. The lens of the eye showing in Fig. 2F does appear to be missing, possibly due to scavenging by birds. There was a small bite in the midsection, the tail was missing and the dorsal fin was buried in the sand. No tissues or parts were kept.

15) 1 June 2015. Tyler Dvorak and Amy Catalano discovered an estimated 4.32 m (14.2 ft) oarfish on Santa Catalina Island, stranded along Emerald Bay (Fig. 2G). The fish was reported to Catalina Island Conservancy, necropsied, and shipped to California State University, Fullerton, for further study and CT scanning at UCLA (Paig-Tran et al. 2016). Muscle tissue is frozen at the LACM (T-001252). Reproductive tissue indicated it was a female (Forsgren et al. 2017).

16) 30 June 2015. An oarfish was snagged with rod and reel and brought to the surface on the fishing boat *Fortune*, off Salta Verde Point at Santa Catalina Island over 9 m depth (Fig. 2H). It was estimated to be about 6.1 m (20 ft). The captain, Bruce Smith, said it may have been alive at the time. The fish was gaffed but its flesh started to tear so it was released and not seen again after that.

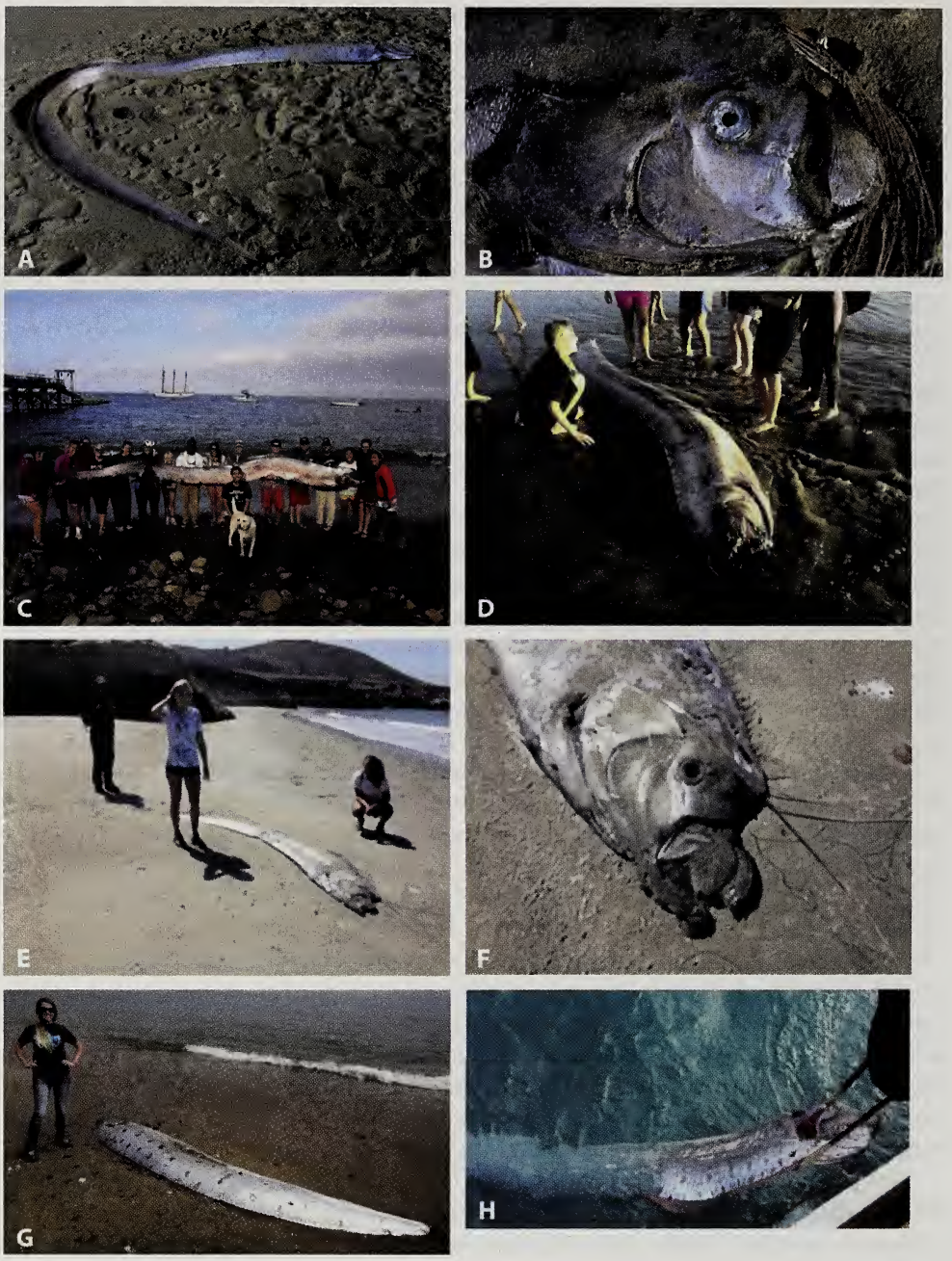

Fig. 2. **A** Oarfish at Surf Beach, Lompoc, 2011. **B** head, image by John Downs. **C** Santa Catalina oarfish, Toyon Bay, 2013, courtesy of CIMI. **D** Oceanside oarfish, 2013, by Mark Bussey, Associated Press, LA Times, 22 October 2013. **E** Santa Rosa Is. oarfish, 2014, **F** head, by Patricia Malone. **G** Amy Catalano and oarfish, June 2015, Catalina Is, by Tyler Dvorak, courtesy of Catalina Is. Conservancy. **H** Salta Verde Point, Santa Catalina Island, June 2015, by Bruce Smith.

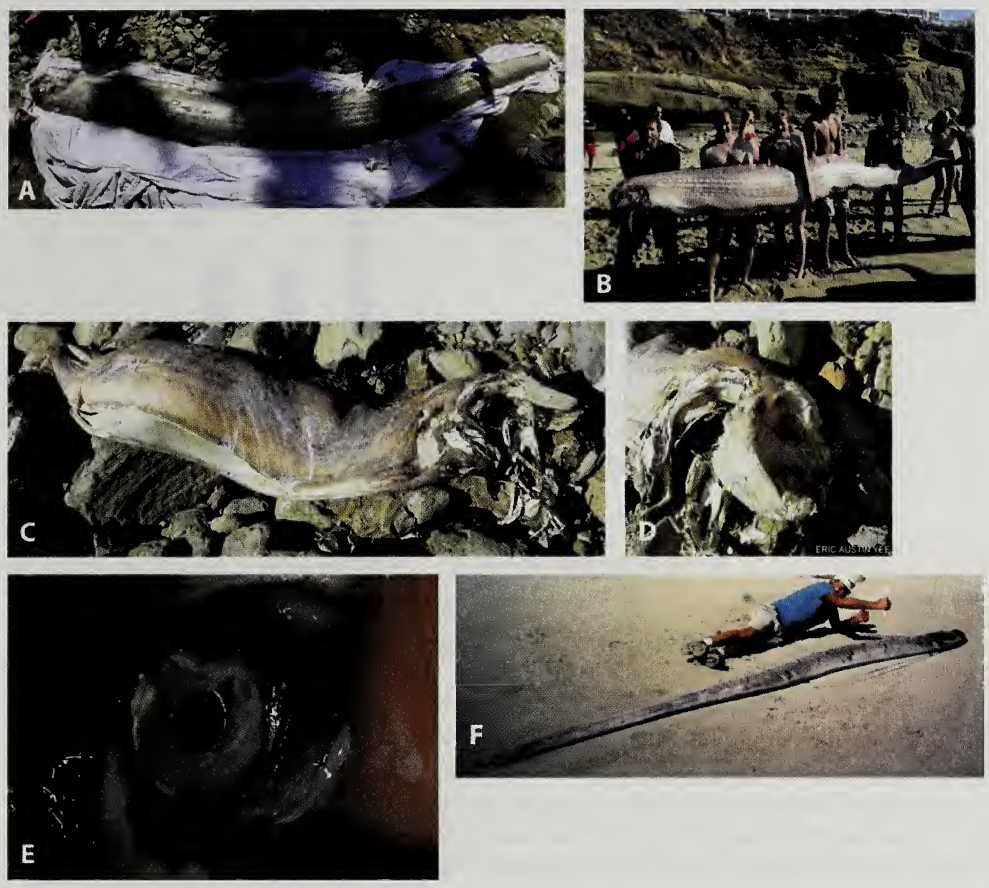

Fig. 3. **A** Specimen stranded near Avalon, Santa Catalina Island, August 2015, by Charles Kelly. **B** La Jolla, September 2015, image from Nick Wegner, SFSC. **C** Carcass at Palos Verdes, November 2015. **D** Close-up of head, by Eric Austin Lee. **E** Eye when fresh, image from Erin Paig-Tran. **F** Oarfish stranded on Ensenada de los Muertos, Baja California Sur, 1995, image by Sandra Frederickson.

17) 17 August 2015. An estimated 4.3 m (14.1 ft) long oarfish was discovered at Pebbly Beach, near Avalon, Santa Catalina Island, by an employee of Mountain and Sea Adventures (Fig. 3A). It was freshly dead with little decay; however, the tail was missing. There was krill in its stomach (per. com. Erin Paig-Tran of California State University, Fullerton. Tissues and parts (California State University at Fullerton) were retained and scanned. It was determined to be a male (Forsgren et al. 2017). Samples are being examined for parasites by the Ecological Parasitology Lab at the University of California, Santa Barbara.

18) 14 September 2015. An oarfish washed ashore in La Jolla at Shell Beach (Fig. 3B). It was 5.21 m (17.1 ft) long. National Marine Fisheries Service staff from the Southwest Fisheries Science Center retrieved it. Tissues, photographs, and records are at Scripps Institution of Oceanography (SIO 15-37) per. com. Phil Hastings, Curator, Marine Vertebrate Collection. Samples were CT scanned for hyperostosis (Paig-Tran et al. 2016) and reproductive tissues indicated it was a female (Forsgren et al. 2017).

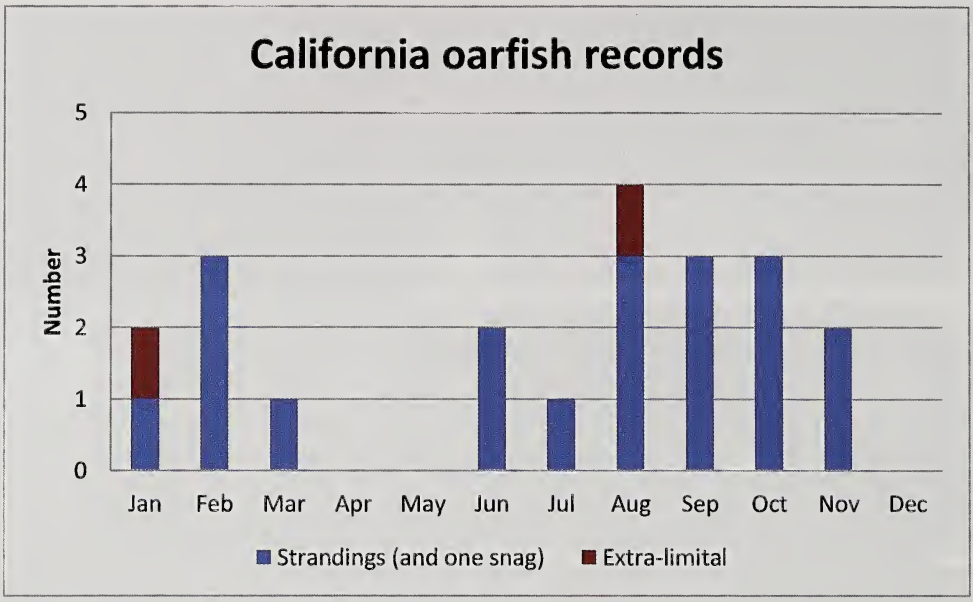

Fig. 4. Oarfish records by month.

19) 3 November 2015. An oarfish was discovered by tourists at Rancho Palos Verdes, right below the Trump National Golf Course (per. com. Erin Paig-Tran, California State University at Fullerton, Fig. 3C-E). Dr. Paig-Tran's students dissected it and took samples the next day. They recorded the fresh length as 4.1 m (13.4 ft) and reported it still had red fins and silver skin. Samples were CT scanned for hyperostosis (Paig-Tran et al. 2016) and it was a male (Forsgren et al. 2017). The dried carcass remaining on the beach was then examined by Eric Austin Lee on November 6th. He estimated the dried length at about 2.1 m (7 ft) and kept the badly decomposed head for the Aquarium of the Pacific, Long Beach, CA. Samples are being examined by the Ecological Parasitology Lab, University of California, Santa Barbara.

Records with limited data.—A smaller 2.2 m (7.2 ft) oarfish was on display with the larger 1970 oarfish for years in the Museum Foyer. Robert J. Lavenberg (per. com.) recalls Boyd Walker (University of California, Los Angeles) received it from lifeguards in Santa Monica Bay in good shape and then donated it to the LACM. We have no other data (LACM 58185-1). Dirk Nolf (1985, fig. 56E) illustrates a *Regalecus* 1.4 mm otolith that matches a 1.4 mm otolith in the Fitch Collection that has ">244 cm" written on the capsule. It may be the same fish since the body lengths are similar.

An oarfish skeleton is cataloged at the Santa Barbara Museum of Natural History (SBMNH OS 4904) collected in 1996 but with no specific locality. It is possibly from Santa Barbara County. The preopercle is 120 mm in length, vertebrae about 35 mm and the longest dorsal ray is about 700 mm long, indicating a large fish, likely 3-4 meters in length.

Extra-limital records (taken at sea or off northern Baja California).—A) 7 August 1961. An oarfish estimated as ca. 4.6 m (15 ft) was encountered by the sportfishing vessel Beverly 80 mi. SW of San Diego (off Baja California, Mexico). The oarfish was noted by the vessel Captain, E. Galvin, as being under attack by sharks at the surface prior to being gaffed. The head, in a battered condition, and a 1 m section of the tail from near the caudal were salvaged. Parts of the specimen were donated to Scripps; the cranium went to

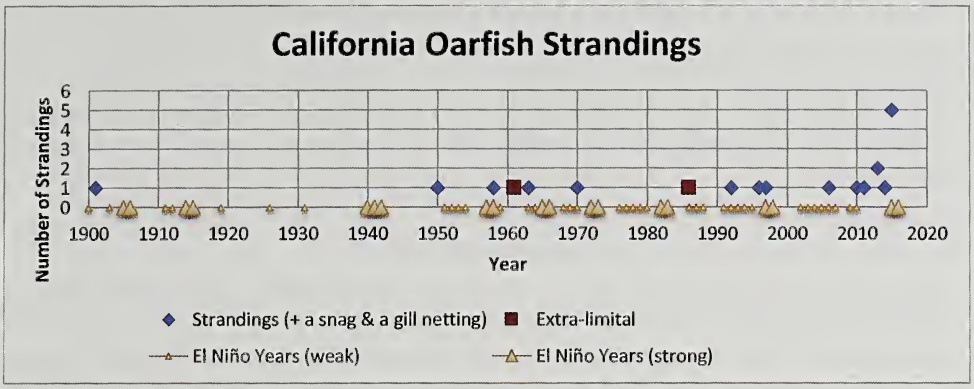

Fig. 5. Oarfish strandings by year, with El Niño years based on http://www.bom.gov.au/climate/enso/enlist/ https://www.esrl.noaa.gov/psd/enso/past_events.html.

J. E. Fitch, California Department of Fish and Game, and the brain was sent to Vladimir Walters, UCLA. SIO 61-389.

B) 24 January 1986. A 4330 mm (14.2 ft) specimen was caught south of San Juan Seamount, over "1830 Bank," 32°30.0′N 121°0.0′W. The oarfish (SIO 86-1) was taken by the F/V Temptation with a drift gill net.

Summary.—There are no known records of *Regalecus* north of Central California in the northeastern Pacific. All of the California records are from strandings, except one that was caught in a gill net and one that was snagged by hook and line. The extra-limital specimens were caught offshore in trawls or were gaffed. The peak months were August and February (Fig. 4) in a bimodal pattern. No strandings occurred in April, May, and December.

In 1901 there was a stranding near Newport Beach and then none reported until 1950. More strandings have been seen recently (Fig. 5). In the fall of 2013 there were two strandings that coincided with the appearance of a warm water "blob" in the North Pacific (Bond et al. 2015; Kintisch 2015). In 2015 that dramatically increased to five strandings. California experienced a strong El Niño event starting in 2015, lasting into 2016, with warm water, and the appearance of tropical fishes such as Blue Marlin, Wahoo, Yellowtail Jack and Bigeye Scad (Feeney and Lea 2016; Love et al. 2015). No California sightings of oarfish occurred in 2016 or as yet in 2017.

Most northeastern Pacific records of *Regalecus* are from Mexico and Central America, numbering 45 records between 1979 and 2014 (Galván-Magaña, et al. 1999; Salazar-Hermoso 1999; Roberts 2012, Angulo and López-Sánchez 2017), including two sightings since 2012, and one unpublished record from 1995 in the LACM files.[1] There are no records from 2015 to June, 2017 south of California. Multiple occurrences are common to the south; in 1991 there were seven occurrences in Mexico. In 1995 there were six records of oarfish in Mexico and Costa Rica. The most frequent months of the strandings also had

[1]On 24 March 1995, according to the files at the LACM, a 4.9 m (16 ft) specimen was stranded on Ensenada de los Muertos, Baja California Sur, Highway 286, 21.6 km from Los Planes. It was photographed by Sandra Frederickson and party (Fig. 3F). The tail was missing. The pictures, negatives and a letter were sent from Ms. Frederickson to the LACM on 10 April 1995. The date and locality do not match any record listed in published references relating to Sea of Cortez strandings (Galván-Magaña et al. 1999; Salazar-Hermoso 1999; Roberts 2012).

a bimodal pattern, with a peak from March to September and again from December to January; no oarfish are reported in February or November. The recent numbers in both Mexico and California in the eastern Pacific indicate an increasing trend in sightings. Not all past sightings coincided with an El Niño event (Fig. 5). There is, however, an increasing trend in sea surface temperatures during 1900-2012 of about 0.5-1.0°C (Johnstone and Mantua 2014).

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Asemichthys taylori Gilbert, 1912, Spinynose Sculpin, New to the California Marine Fauna

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On 21 June 2017, Author K. Lee, diving in 29 m of water at Esalen Pinnacle (36°07.6′N, 121°39′W), central California, photographed a fish we have identified as *Asemichthys taylori* Gilbert, 1912 [referred to by some authorities as *Radulinus taylori* (Gilbert 1912)], the spinynose sculpin (Fig. 1). We identified this fish through a combination of characters that we have compared with *Radulinus asprellus* Gilbert, 1890 (slim sculpin) and *Radulinus boleoides* Gilbert, 1898 (darter sculpin), the two species *A. taylori* most closely resembles (Table 1). The most diagnostic characters for this specimen are possession of 1) a dark lower half of the head, 2) a light band behind the eye, and 3) blue edging to some of the saddles (Table 1). Other characters that we can gauge from the photograph, including number of pectoral rays, number of scale rows behind the eye, and the relation of orbit width into snout length, all tend to confirm our identification (Table 1). Visual comparison of an image of *R. asprellus* (Figure 2) with both the central California and British Columbia fishes clearly demonstrates a range of differences including long nasal spines in *R. asprellus* (lacking in *A. taylori*), as well as a lack of the diagnostic characters listed above. Lastly, this specimen compares well with that of an *A. taylori* photographed within its previously known range in the San Juan Islands, Salish Sea (Fig. 3).

Asemichthys taylori was originally collected in Departure Bay, Vancouver Island (about 49°12′N, 123°58′W) (Gilbert 1912). All subsequent captures have occurred in a relatively restricted area from southeastern Alaska, at the junction of Sumner and Clarence straits off Strait Creek (56°12′N, 133°15′W) (Love et al. 2005), to Keystone Jetty, Whidbey Island, Puget Sound (Kent et al. 2011). This new record represents a geographic range extension of about 1,400 km (870 mi). The maximum size of this species is 7.4 cm (Peden and Wilson 1976) and its documented depth range is 5–27 m (min.: Peden and Wilson 1976; max.: this paper). An undocumented capture has been reported at a depth of 49 m (W.A. Palsson, pers. comm. to M.L.).

Relatively little is known of this species biology and behavior. In Washington State it typically occurs in the shallow subtidal on fragmented-shell bottoms adjacent to rock reefs (G.C. Jensen, pers. obs.) and is rarely taken in trawls. Spawning occurs at least during February and March in subtidal waters. At least in southern British Columbia spinynose sculpin exclusively lay their eggs in the nests of *Enophrys bison* Girard, 1854, the buffalo sculpin (Kent et al. 2011). Eggs are usually green in color, but may also be pink or orange. While it feed on a variety of crustaceans and bivalves, this species appears to be unique among cottids in ingesting large numbers of snails (Norton 1988). Upon capturing a snail, the sculpin punches holes in the gastropod's shell using specialized vomerine teeth.

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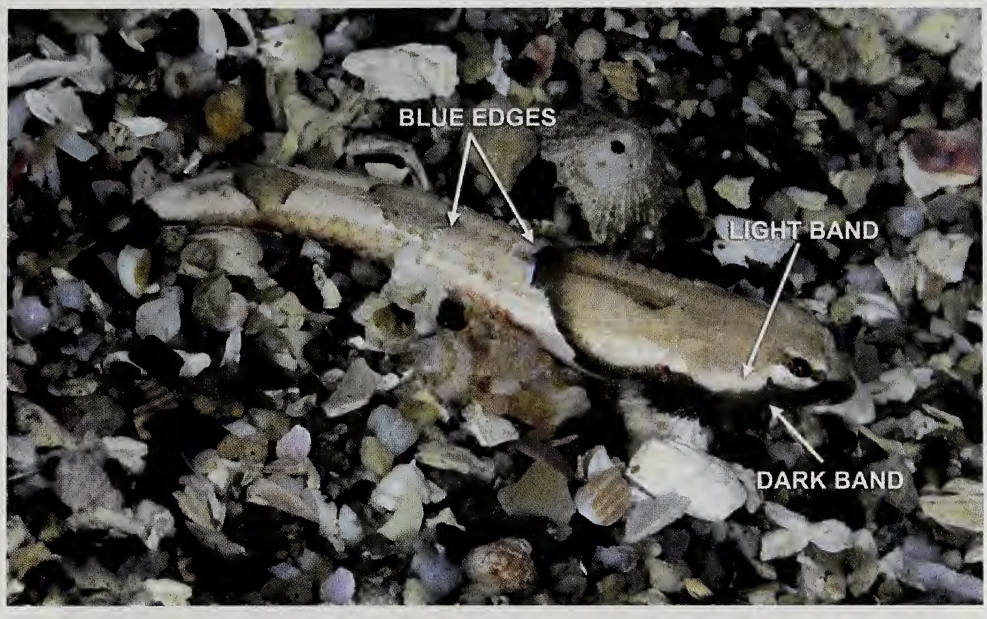

Fig. 1. *Asemichthys taylori* photographed in 29 m of water at Esalen Pinnacle (36°07.6′N, 121°39′W), central California by K. Lee. Three of the diagnostic characters are denoted.

It is likely that the Esalen Pinnacle fish was not an isolated expatriate. Rather, it is more likely that this diminutive, secretive, and economically unimportant fish, lying still and blending in to shell hash or sand, is rarely observed or caught. It is interesting to note that the one large collection of this species, 105 individuals from the San Juan Islands (Norton 1988), was made by a researcher who focused on capturing this species. Lastly, we acknowledge the possibility that this specimen might be an undescribed species that

Table 1. A comparison of diagnostic characters of *Asemichthys taylori*, *Radulinus asprellus*, and *R. boleoides* and the fish photographed.

	A. taylori	This Specimen	*R. asprellus*	*R. boleoides*
Dark lower half of head	Yes[1,2]	Yes	No[1]	No[1,2]
Light band behind eye	Often[1,2]	Yes	No[1,2]	No[1]
Pectoral rays	16–19[5]	17	17–20[4]	18–20[5]
Lateral line scales	34–36[3]	about 35	38–41[3]	39–40[3]
Scale rows behind eye	1–4[3]	Multiple	13	13
Some saddles edged in blue	Usually[2]	Yes	No[2]	—
Orbit width into snout length	1.16	0.7	0.7–1.0[7]	1.2–1.5[4]

[1]Lamb and Edgell (2010).
[2]Jensen (2014).
[3]Hart (1973).
[4]Bolin (1944).
[5]Ichthyoplankton Information System.
[6]Gilbert (1912) (based on a single specimen).
[7]Mecklenburg et al. (2002).

Fig. 2. *Asemichthys taylori* photographed at 12 m depth at Bordelais Islets (48°48.98′N, 125°13.9′W), Barkley Sound, British Columbia by G. C. Jensen. Note 1) dark lower half of the head, 2) light band behind the eye, and 3) blue edging to some of the saddles, characters identical to those in the Esalen Pinnacle fish.

Fig. 3. *Asemichthys asprellus* photographed at 18 m depth at Ayer's Point, Hood Canal, Washington by G. C. Jensen. Note the extremely long nasal spines that are absent in *A. taylori.*

is closely related to *A. taylori*. However, given the extreme similarity of this specimen to known *A. taylori* individuals we believe that scenario to be remote.

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We thank Rick Feeney for confirming the identification of this specimen.

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The Panamic Fanged Blenny, *Ophioblennius steindachneri* Jordan & Evermann, 1898, New to California Marine Waters with a Key to the California Species of Blenniidae

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We report here on the first observations of the Panamic fanged blenny, *Ophioblennius steindachneri* Jordan & Evermann, 1898, in California marine waters. In addition, we provide information on the other blenniid species found off California and include a key to all of the California taxa.

On 3 June 2017, William Bushing was diving in the Casino Point Dive Park, Santa Catalina Island (about 33°20.98′N, 118°19.57′W) when he observed a chocolate-brown blenny in a high surge zone at a depth of about 3 m resting on a small ledge in a rocky outcropping (Fig. 1). Based on his experiences filming this species in the Gulf of California, Bushing was confident the individual was *O. steindachneri* but sent images to Milton Love for confirmation. Based on the following characters we determined that this fish was *O. steindachneri*: 1) In the eastern Pacific, the short and blunt head with the slanted profile is characteristic of only two species, both members of the genus *Ophioblennius*: *O. steindachneri* and *O. clippertonenesis* Springer, 1962 (Springer 1962, Robertson and Allen 2015). *Ophioblennius clippertonensis* is a Clipperton Island endemic and 2) lacks a diagnostic character found in the Santa Catalina specimen, a dark ocellus posterior to the eye. 3) In addition, this individual had blue edging on its pectoral and anal fins, coloration found on many *O. steindachneri* (Humann and DeLoach 2004, Robertson and Allen 2015, Froese and Pauly 2017). Bushing continued to observe this individual in the same location for about one month after its first sighting.

On 18 June 2017, Bushing observed a second Panamic fanged blenny about 30 m from the first one (Fig. 2) also in about 3 m of water in a similar habitat similar. Along with a dark ocellus and the blue on the pectoral fin, this individual had faint banding on the sides a pattern often seen in this species (Humann and DeLoach 2004, Robertson and Allen 2015, Froese and Pauly 2017).

We note that these were not the first documented sightings of this species in California waters. To our knowledge, the first sighting was by Rob Anslow on 23 July 2015 at Sea Fan Grotto (about 33°26.6′N, 118°28.4′W), Santa Catalina Island. He observed this fish swimming among boulders in about 3 m of water. This fish (https://www.youtube.com/watch?v=FPu8OHDdloY), identified from the video on 24 June 2016 by William Bushing, resembled the first individual Bushing encountered; brown and unmarked except for a dark ocellus behind the eye, with extensive blue edging on the pectoral and anal fins. Lastly, Ruth Harris observed a fish in June 2017, in the same general

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Fig. 1. An *Ophioblennius steindachneri* photographed by William Bushing 3 June 2017 in the Casino Point Dive Park, Santa Catalina Island. Note the chocolate brown coloration and the ocellus posterior to the eye.

Fig. 2. An *Ophioblennius steindachneri* photographed by William Bushing 18 June 2017 in the Casino Point Dive Park, Santa Catalina Island. Note the lighter vertical bars on head and posterior part of body.

vicinity as the two Casino Point Dive Park fish, and her description matches the Panamic fanged blenny.

Ophioblennius steindachneri is primarily a tropical species previously known as far north as Isla Guadalupe, northern Baja California (SIO 57-190) and extending southwards throughout almost all of the Gulf of California and to Peru, including all of the islands off of Baja California, Mexico, Central America and northern South America, with the exception of Clipperton Island (Love et al. 2005, Robertson and Allen 2015). At mainland sites, it appears to be most abundant from mid-Gulf of California to at least Ecuador (Robertson and Allen 2015, Academy of Natural Sciences, Philadelphia Collection Numbers ANSP 102686, ANSP 102690).

Based on the observations detailed above, it appears that this species has lived at Santa Catalina Island since at least the summer of 2016 and may be yet another immigrant from the 2015 El Niño (Love et al. 2016a, 2016b). We note that this species has a relatively long larval duration (about 50 days, Riginos and Victor 2001). This compares to shorter ones of such other tropical reef taxa such as *Axoclinus nigricaudus* Allen & Robertson, 1994 (18 days, Riginos and Victor 2001) and *Malacoctenus hubbsi* Springer, 1959 (about 24 days, Riginos and Victor 2001) which have not yet established themselves off California.

Miller and Lea (1972) provided descriptions of three blenniid species, all members of the genus *Hypsoblennius*, from California waters. These sightings of *O. steindachneri* bring to five [with the earlier addition of *Plagiotremus azaleus* (Pondella and Craig 2001)] the number of species of Blenniidae known to occur here (Table 1). We provide a key to all California species.

Key to the Blennies of California

1a No cirri over eyes, body slender with dark stripe along body from snout through eye to caudal fin; mouth subterminal; fewer than 10 dorsal spines, more than 30 dorsal rays ..... *Plagiotremus azaleus*

1b Cirri over eyes (may be difficult to see on females of *Hypsoblennius gentilis*); no dark stripe as in 1a; mouth terminal; more than 10 dorsal spines, fewer than 24 dorsal rays 2

2a Lateral line divided, in two independent and overlapping segments; dark ocellus behind eye; (juveniles appearance different than adults with a black bar across base of caudal fin and red pectoral and caudal fins) ..... *Ophioblennius steindachneri*

2b Single lateral line, not divided in two independent and overlapping segments; no ocellus behind eye 3

3a Cirri over eye serrated on posterior, not divided in long filaments (cirri very small on female, difficult to see without lens, about 1 mm); female with blue spot between 2nd and 3rd dorsal spines (may have orange on back of spot); pectoral-fin rays 11–13 ..... *Hypsoblennius gentilis*

3b Cirri over eye not serrated but divided into long filaments; pectoral-fin rays generally 13–15 (*Hypsoblennius jenkinsi* may have 12) 4

4a Cirri over eyes divided into 7 or more filaments; lateral line arched; lateral line extends to at least midpoint of anal fin ..... *Hypsoblennius gilberti*

4b Cirri over eye fewer than 7 filaments; lateral line not arched; lateral line ends near start of anal fin ..... *Hypsoblennius jenkinsi*

Table 1. Blennies (Family Blenniidae) collected or observed in California marine waters. SIO = Scripps Institution of Oceanography Marine Vertebrate Collection, CAS = California Academy of Science Fish Collection.

Hypsoblennius gentilis (Girard, 1854). **Bay Blenny**. To 14.7 cm TL (Miller and Lea 1972). Monterey Bay, central California to Gulf of California (Miller and Lea 1972). Intertidal and to 24 m (Miller and Lea 1972).
Hypsoblennius gilberti (Jordan, 1882). **Rockpool Blenny**. To 17 cm TL (Miller and Lea 1972). San Francisco Bay, northern California (CAS 58489) to Puerto Los Cabos, just northeast of Cabo San Lucas, Baja California (J. Snow, pers. comm. to M. L.) to Cabo Pulmo, Baja California, just inside the Gulf of California (SIO 76–284). Usually intertidal and subtidal; to 18 m (Eschmeyer and Herald 1983).
Hypsoblennius jenkinsi (Jordan & Evermann, 1896). **Mussel Blenny**. To 13 cm TL (Eschmeyer and Herald 1983). Morro Bay, central California (J. Stephens, pers. comm. to M. L.) to Punta Marquez, southern Baja California and Gulf of California (Miller and Lea 1972). Intertidal and to 21 m (min.: Wells 1986; max.: Miller and Lea 1972).
Ophioblennius steindachneri Jordan & Evermann, 1898. Large-banded Fanged Blenny or **Panamic Fanged Blenny**. To 18 cm TL (Allen and Robertson 1994). Catalina Island, southern California (this paper), Isla Guadalupe, central Baja California (SIO 57-184), Isla Cedros (M. L., unpubl. data) and (mainland) Arricefe Sacramento (29°40′N, 115°47′W; M. L., unpubl. data), central Baja California into northern Gulf of California to Isla Angel de la Guarda (Thomson et al. 1979) and to Islas Lobos de Afuera, Peru (Chirichigno and Vélez 1998), including Islas Galápagos (Grove and Lavenberg 1997). Tide pools to 12 m (min.: Weaver 1970; max.: Aburto-Oropeza and Balart 2001) and perhaps to 20 m (66 ft; Robertson and Allen 2002).
Plagiotremus azaleus (Jordan & Bollman, 1890). **Sabertooth Blenny**. To 10.2 cm TL (Robertson and Allen 2002). King Harbor, southern California (Pondella and Craig 2001); Rocas Chester (27°53′N, 115°03′W), Isla Cedros, central Baja California (Pondella and Craig 2001) and Islas San Benito (Pondella and Craig 2001) to Puerto Pizarro, Peru (Chirichigno and Vélez 1998), including Gulf of California (Allen and Robertson 1994), Islas Galápagos (Grove and Lavenberg 1997), and many other offshore islands (Robertson and Allen 2002). At depths of 1.5–25 m (min.: Pondella and Craig 2001; max.: Robertson and Allen 2002).

Acknowledgments

We thank the following researchers who reviewed the blenny key: Don Buth, Craig Campbell, Dario Diehl, Rick Feeney, Robin Gartman, Pete Major, Jim Mann, Mike Mengel, Julianne Passarelli, Terra Petry, Jim Rounds, and Fred Stern. We thank Ruth Harris and Rob Anslow for generously sharing information regarding their sightings. Monica Pessino assisted with the figures.

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Where the Weird Things are: A Collection of Species Range Extensions in the Southern California Bight

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Abstract.—A large-scale monitoring program associated with the establishment of a marine protected area network in southern California provided an opportunity to observe and document unique or rare species across the region. Scientists and students from several educational and research institutions surveyed 145 subtidal reefs, 39 intertidal reefs, and five sandy beaches from 2011–2017, a period of time where oceanographic and climatic conditions changed serially and dramatically. In conjunction with an increase in monitoring frequency and locations, dramatic shifts in oceanographic climate during this same time period likely caused shifts in tolerable habitat conditions for many nearshore species. Here we describe range extensions, both to the north and south, of 14 marine fish, invertebrate, and algae species as observed during the 2011–2012 South Coast MPA Baseline Program and subsequent monitoring efforts.

The Southern California Bight (SCB) spans a significant environmental gradient and is subject to the influx and removal of species based upon subtle regional changes as well as large-scale changes in climate and oceanographic conditions. Past reports of new or unusual species to the SCB were typically a product of large-scale oceanographic phenomena such as El Niño/Southern Oscillation events (Engle and Richards 2001; Richards and Engle 2001; Pondella and Allen 2001; Radovich 1961), increases in invasive species vectors through port expansion (Haaker 1979; Pondella and Chinn 2005), new capture/observation technologies, or simply a product of motive and opportunity. The opportunity to observe and document a unique or rare species across the entirety of the SCB presented itself with the establishment of marine protected areas (MPAs) in southern California and the subsequent baseline monitoring program for those newly established MPAs in the South Coast Study Region (SCSR).

Here we describe extensions of published geographical ranges of species as noted during the baseline (2011–2012) characterization surveys of the SCSR, specifically the Kelp and Shallow Rock Ecosystems (Pondella et al. 2015) and Rocky Intertidal Ecosystems (Blanchette et al. 2015) surveys, as well as subsequent and additional monitoring efforts by these programs. The original baseline studies surveyed 39 intertidal reefs and 94 subtidal reefs (to 30 m) from Government Point (near Point Conception) to Cabrillo National Monument (near the US/Mexico border), including all eight of California's Channel Islands and Begg Rock. The inclusion of 51 additional subtidal reefs in

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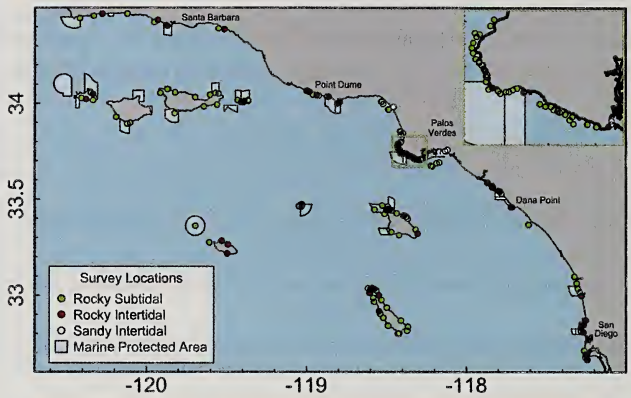

Fig. 1. Map of SCB sampling locations for rocky subtidal (green circles), rocky intertidal (red circle), and sandy intertidal surveys (white).

subsequent monitoring efforts increased the number of subtidal reefs surveyed in the SCSR during 2011–2017 to 145. During this same time period, five sandy intertidal areas in Los Angeles County were also surveyed by biology classes from Occidental College (Fig. 1).

In addition to increased monitoring frequency and locations, there have been dramatic shifts in oceanographic climate during this same time period. The beginning of 2012 marked the end of a nearly two-year long La Niña event and the beginning of a 32-month period of El Niño/Southern Oscillation (ENSO) neutral conditions.[1] By late 2013, an anomalous mass of warm water ("the blob"; Bond et al. 2015) began to spread from the northeast Pacific to as far south as Mexico, increasing sea surface temperatures up to 2.5°C above normal. In conjunction with this anomaly, one of the strongest and most persistent El Niños recorded began in late-2014 before finally fading in May of 2016.[1] These Pacific Ocean-wide oceanographic anomalies created large fluctuations in local sea surface temperatures throughout the SCSR monitoring program and beyond (Fig. 2). These serial changes in oceanographic climate during this same time period are known to alter the existence and strength of oceanic circulation within the SCB, specifically with respect to the Davidson Countercurrent (McClain and Thomas 1983), and likely caused shifts in tolerable habitat conditions for many nearshore species (Engle and Richards 2001; Richards and Engle 2001; Tegner and Dayton 1987; Love et al. 2015; Love et al. 2016; Love 2016; Pondella and Allen 2001, Radovich 1961). These environmental changes coincided with a period of intensive biological monitoring (both in temporal frequency and high number of locations), providing numerous opportunities to observe even temporary excursions of species outside their typical biogeographic borders. During this time, we observed fourteen species range outside of their typical range in the SCB (Table 1).

Materials and Methods

Range extensions described herein were observed as a product of three separate monitoring programs, two of which were related to MPA baseline monitoring of the SCSR. Kelp

[1] Climate Prediction Center. 2016. Historical El Nino/La Nina episodes. Available from: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml. Accessed 17 September 2016.

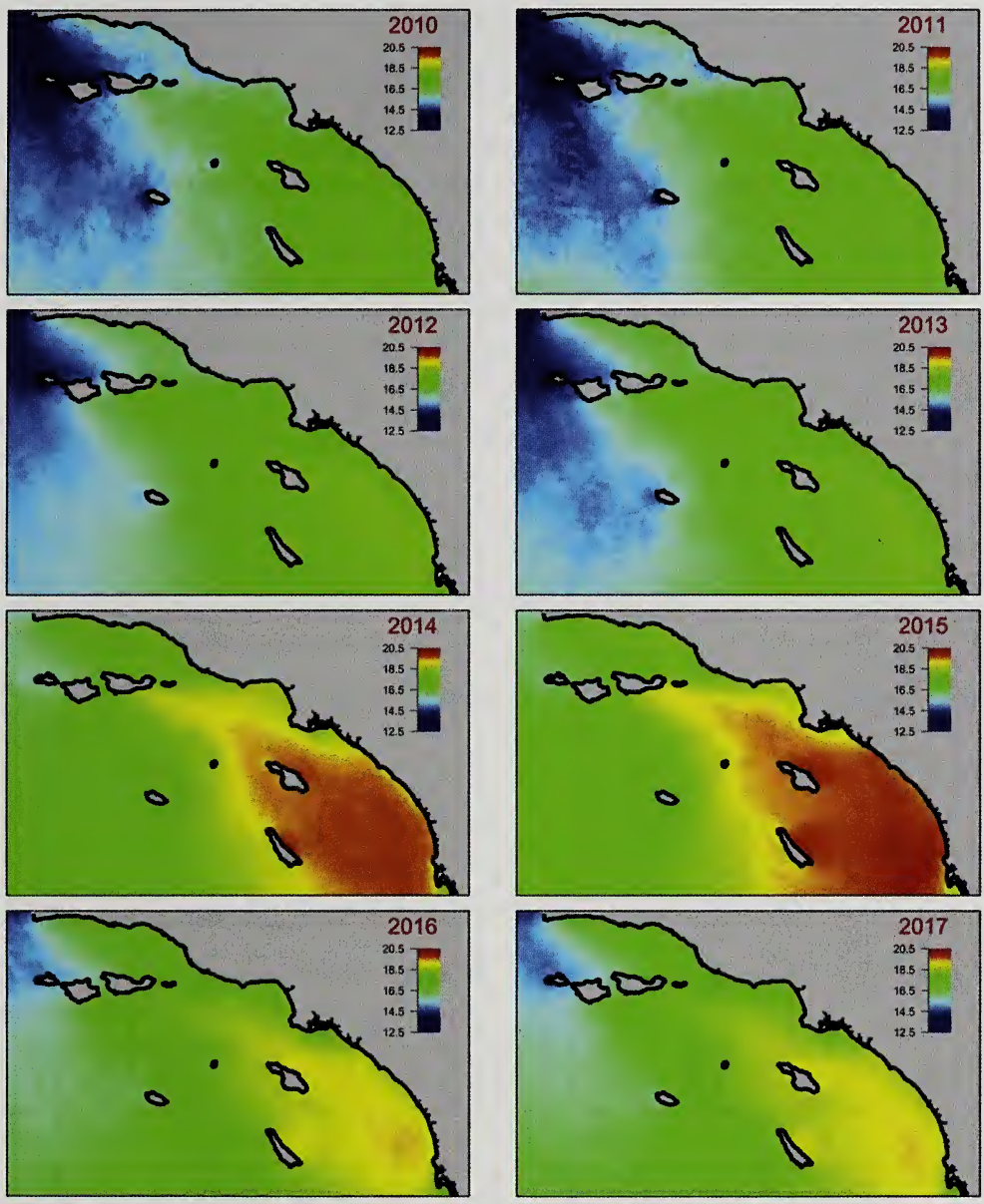

Fig. 2. Annual mean sea surface temperature data shown from 2010–2017. SST data were obtained from merged MODIS 1 km resolution data from MODIS-Aqua, MODIS-Terra, and VIIRS-NPP composited over 15-day intervals by the California Current Ecosystem Long-Term Ecological Research program based at Scripps Institution of Oceanography (available from: http://www.wimsoft.com/CAL/).

and Shallow Rock Ecosystems monitoring was performed by the Vantuna Research Group (VRG) at Occidental College and the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO). At each site fish, invertebrates, and algae were surveyed by divers using band transects and/or benthic point contact surveys at various depths (3-30m) on rocky

Table 1. List of species with descriptions of previously described range limits, new localities, direction and scale of range extension, and categorizations for classifying overall confidence in potential range extensions, following rapid-assessment classification trees in Robinson et al. (2015). "Present in Winter" classification from Robinson et al. (2015) was replaced with "Anti-forcing Presence" (e.g. found north of previously described limits during a below average SST year) to reflect oscillation of oceanographic conditions during the study period. Y = Yes, N = No, H = High, M = Moderate, L = Low, S = Strong, W = Weak.

Species	Previous Limit	Extension Direction	New Locality	Scale of Extension	Boundary Confidence	Mobility	Multi-year Presence	Anti-forcing Presence	Detectability	Strength of Consistency	Overall Confidence
Analipus japonicus	Point Conception, CA	South/ Island	Crook Point, San Miguel Island, CA	50 km; first Channel Island Nat'l Park record	H	L	N	Y	L	M	M
Desmarestia dudresnayi subsp. *foliaceae*	Monterey Bay, CA	South	Resort Point, Palos Verdes, CA	500 km	H	L	Y	N	L	M	M
Saccharina latissima	Santa Catalina Island, CA	South	Matlahuayl State Marine Reserve, La Jolla, CA	100 km	H	L	N	N	L	W	L
Nereocystis luetkeana	Point Conception, CA	South	Castle Rock, San Clemente Island, CA	225 km	H	L	N	Y	H	W	L
Odonthalia floccosa	Government Point, CA	South	Crystal Cove, Laguna Beach, CA	250 km	H	L	N	Y	L	M	M
Osmundea sinicola	Santa Cruz Island, CA	North	Coal Oil Point, CA	40 km	H	L	N	N	L	W	L
Polymastia pacifica	San Nicolas Island, CA	Mainland	Long Point, Palos Verdes, CA	First mainland record for SCB	L	L	N	N	H	W	L
Trikentrion helium	San Onofre, CA	North	Ridges, Palos Verdes, CA	100 km	L	L	Y	Y	H	S	L
Schuchertinia milleri	Southern CA	South	Long Point, Palos Verdes, CA	unknown	L	L	Y	Y	H	S	L
Savalia lucifica	Santa Catalina Island, CA	North	Abalone Cove, Palos Verdes, CA	30 km	H	L	Y	Y	H	S	H
Lovenia cordiformis	San Pedro, CA	North	KOU Rock, Palos Verdes, CA	5 km	H	L	N	N	L	W	L
Ophionereis annulata	San Pedro, CA	North	Honeymoon Cove, Palos Verdes, CA	15 km	H	L	N	N	L	W	L
Hyporhamphus rosae	Santa Ana River, CA	North	Marina del Rey, CA	60 km	H	L	N	N	H	W	L
Isopsetta isolepis	Ventura, CA	South	Cabrillo Beach, San Pedro, CA	110 km	H	L	N	N	L	W	L

reefs.[2] These 145 sites were surveyed between one and eight times from 2011–2017 with each survey covering between 240 m^2 and 960 m^2 depending on the reef's depth range. Rocky Intertidal Ecosystems monitoring was performed by the University of California Santa Barbara, the University of California Santa Cruz, California State University Fullerton, Cal Poly Pomona, and NOAA Channel Islands Marine Sanctuary. This monitoring program also utilized band transects as well as quadrats to survey invertebrate and algal species.[3] These 39 sites were each surveyed a single time from 2012–2013, covering between 100 m^2 and 1,800 m^2 depending on the land-to-ocean length of the rocky intertidal area. Sandy intertidal areas were sampled sporadically for fishes by students at Occidental College using a 30-m × 1.8-m beach seine equipped with a 1.8-m × 1.8-m × 1.8-m bag (1.2-cm mesh wings and 0.6-cm mesh in bag) at a depth of 0-2 m. The five survey locations were each sampled annually from 2011–2017 with estimates of total areal sampling at each site ranging from 974 m^2 to 8,766 m^2. For each species range extension reported below, photographs were taken and/or voucher specimens were collected and curated into the museum collection at the Moore Laboratory of Zoology at Occidental College. Additionally, levels of confidence in potential range extensions were assigned to each species using the rapid-assessment classification described in Robinson et al. (2015), modified to reflect the multi-directional nature of this collection of extensions, sampling methodology, lack of seasonal variation and/or repeated sampling for some methods, and strong forcing from oceanographic conditions (Table 1).

Results

Kingdom Chromista
Phylum Ochrophyta
Class Phaeophyceae
Order Ralfsiales
Family Ralfsiceae

Analipus japonicus (Harvey) Wynne – sea fir

Previous reported range.—Japan (Okamura 1936) north to Alaska, south to Point Conception, CA (Abbot and Hollenberg 1976).

New record.—Crook Point, San Miguel Island, CA

Remarks.—This is the first record of this species inside Channel Islands National Park, and this range extension to the south represents the first observations of this species within the Southern California Bight.

Order Desmarestiales
Family Desmarestiaceae

Desmarestia dudresnayi subsp. *foliaceae* (Pease) Peters, Yang, Küpper and Prud'Homme van Reine (Fig. 3a).

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[2] Pondella, D. J., J. E. Caselle, J. T. Claisse, J. P. Williams, K. Davis, C. M. Williams, and L. A. Zahn. 2015. South Coast baseline program final report: Kelp and shallow rock ecosystems. California Sea Grant, San Diego, CA. 224 pp.

[3] Blanchette, C. A., P. T. Raimondi, R. Gaddam, J. Burnaford, J. Smith, D. M. Hubbard, J. E. Dugan, J. Altstatt, and J. Bursek. 2015. Baseline characterization of the rocky intertidal ecosystems of the South Coast Study Region. California Sea Grant, San Diego, CA. 120 pp.

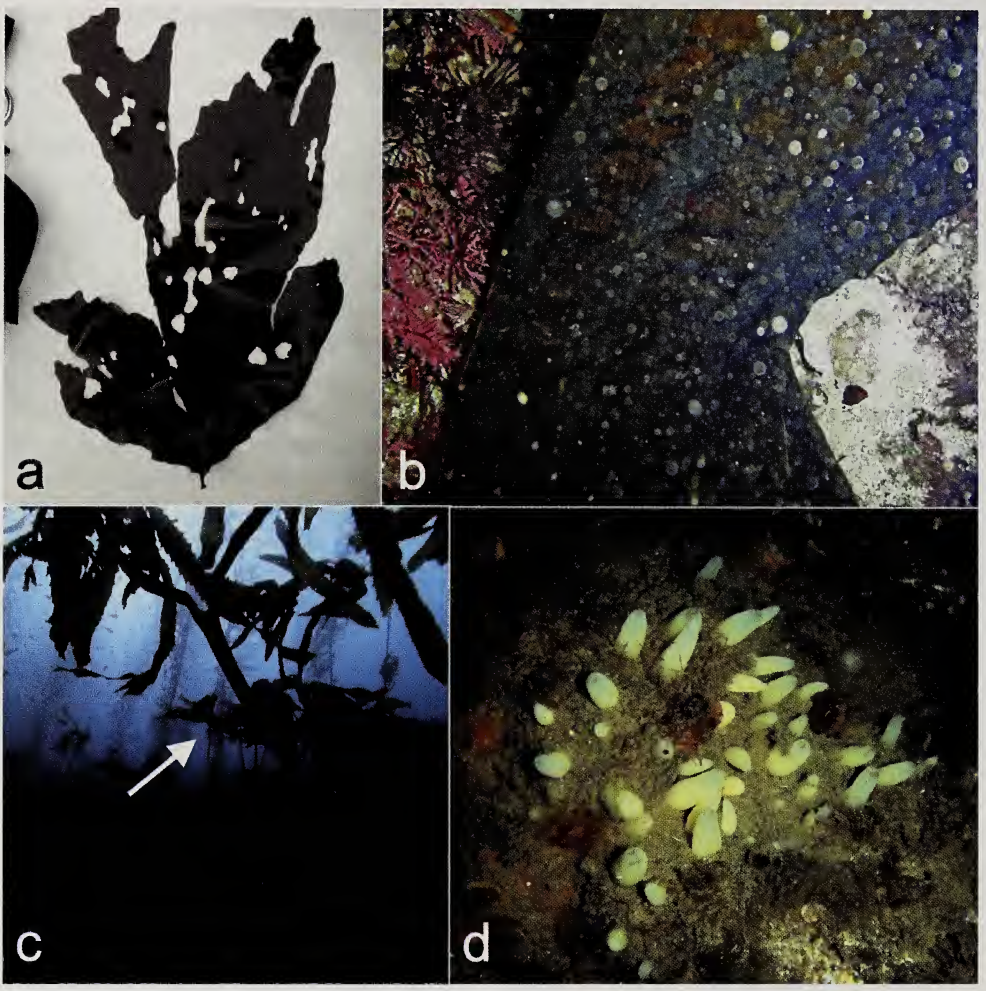

Fig. 3. (a) *Desmarestia dudresnayi* subsp. *foliaceae* from Cairns, Palos Verdes, CA at 5 m depth on 16 October 2015; (b) sugar kelp (*Saccharina latissima*) from Matlahuayl State Marine Reserve, La Jolla, CA at 10 m depth on 15 October 2011; (c) bull kelp (*Nereocystis luetkeana*; white arrow) from Castle Rock, San Clemente Island, CA at 23 m depth on 21 December 2012; (d) aggregated nipple sponge (*Polymastia pacifica*) from Long Point, Palos Verdes, CA at 20 m depth on 12 August 2011. Photos by J.P. Williams.

Previous reported range.—British Columbia, Canada to Monterey Bay, CA (Scagel et al. 1989).

New record.—Cairns (between Whites Point and Point Fermin), Palos Verdes, CA; 5 m depth; 16 October 2015.

Remarks.—These records represent a substantial range extension of approximately 500 km to the south. Individuals were also found at Honeymoon Cove, Palos Verdes on 2 July 2014 and Resort Point, Palos Verdes on 12 August 2014 (both at 10 m depth).

Order Laminariales

Family Laminariaceae

Saccharina latissima (Linnaeus) Lane, Mayes, Druehl and Saunders, sugar kelp (Fig. 3b)

Previous reported range.—Circumboreal south to Santa Catalina Island, CA (Scagel et al. 1989).

New record.—Matlahuayl State Marine Reserve, La Jolla, CA; 10 m depth; 15 October 2011.

Remarks.—We observed many individuals at this site during a particularly cold (8°C) period of time, and represents a greater than 100 km range extension to the south.

Nereocystis luetkeana (Mertens) Postels and Ruprecht – bull kelp (Fig. 3c)

Previous reported range.—Kamchatka Peninsula (Klochkova et al. 2009), Commander Islands (Selivanova and Zhigadlova 1997), Alaska (Abbott and Hollenberg 1976) south to Point Conception, CA (Vadas 1972).

New record.—Castle Rock, San Clemente Island, CA; 23 m depth; 21 December 2012.

Remarks.—A single immature individual approximately 2 m in height was found mixed in giant kelp (*Macrocystis pyrifera*) with southern sea palm (*Eisenia arborea*). While drifted individuals have been observed as far south as San Diego, this observation of an attached individual represents a greater than 200 km range extension to the south and the first record of this kelp in the SCB. Castle Rock is a rocky spine that protrudes from the northwest tip of San Clemente Island and is subject to strong currents from the north. Vadas (1972) posited that water south of Point Conception is too warm for gametophyte fertility and young sporophyte growth, suggesting that this individual is likely a singleton and not part of a sustained range expansion.

Kingdom Plantae
Phylum Rhodophyta
Class Florideophyceae
Order Cermiales
Family Rhodomelaceae

Odonthalia floccosa (Esper) Falkenberg

Previous reported range.—New Caledonia (Payri 2007) and Japan (Yamada 1935) north to Alaska, south to Government Point, CA (Abbot and Hollenberg 1976; Masuda 1998).

New record.—Crystal Cove, Orange County, CA.

Remarks.—These records represent a range extension of nearly 250 km to the south.

Osmundea sinicola (Setchell and Gardner) Nam

Previous reported range.—Santa Cruz Island, CA to Isla Revillagigedo, Mexico, including Gulf of California (Abbot and Hollenberg 1976).

New record.—Coal Oil Point, Santa Barbara, CA.

Remarks.—This observation represents a small (~40 km) range extension to the north.

Kingdom Animalia
Phylum Porifera
Class Demospongiae
Order Polymastiida
Family Polymastiidae

Polymastia pacifica Koltun, 1966, aggregated nipple sponge (Fig. 3d)

Previous reported range.—Aleutian Islands, AK to San Nicolas Island, CA (Gotshall 2005).

New record.—Long Point, Palos Verdes, CA; 20 m depth; 12 August 2011.

Remarks.—Not to be confused with the senior homonym *Polymastia pacifica* Lambe 1893. Found several individuals colonizing a boulder near sand/rock interface, mixed in with brown cup corals (*Paracyathus stearnsi*). May represent the first non-island record in the Southern California Bight.

Order Axinellida
Family Raspailiidae

Trikentrion helium Dickinson, 1945, mitten sponge (Fig. 4a)

Previous reported range.—Guerrero, Mexico to San Onofre, CA (Gomez et al. 2002; Luke 1998; Van Soest et al. 2012).

New record.—Ridges (north of Rocky Point), Palos Verdes Peninsula, CA; 17 m depth; 3 July 2013.

Remarks.—Recorded in many locations along Palos Verdes from 2010–2017 at depths of 15–25m, typically covered in fine sediment. Represents a range extension of nearly 100 km to the north, however there is some confusion over the taxonomic separation of this species and *T. catalina* that may muddle identification of individuals and therefore range descriptions. Identification confirmed with SEM images of spicules showing diagnostic triacts with only one spined ray (Figs. 4b and 4c).

Phylum Cnidaria
Class Hydrozoa
Order Anthoathecata
Family Hydractiniidae

Schuchertinia milleri (Torrey, 1902) – hedgehog hydroid (Fig. 5a)

Previous reported range.—British Columbia, Canada to Carmel, CA (Haderlie et al. 1980); listed as Southern California in Gotshall (2005) with many unpublished observations in Channel Islands National Park, San Nicolas Island and Begg Rock

New record.—Long Point, Palos Verdes Peninsula, CA; 13 m depth; 22 August 2012.

Remarks.—Several records from Palos Verdes in 2012 and 2013 from depths of 15-25 m. This species appears to be fairly common within the northern portion of the SCB, but observations at Palos Verdes Peninsula have not been reported.

Order Zoantharia
Family Parazoanthidae

Savalia lucifica (Cutress and Pequegnat, 1960), luminescent parazoanthid (Figs. 5b and 5c)

Previous reported range.—Santa Catalina Island, CA to San Benitos Islands, Mexico (Gotshall 2005).

New record.—Abalone Cove, Palos Verdes Peninsula, CA; 17 m depth; 27 March 2015.

Remarks.—Found frequently along the southern portion of Palos Verdes Peninsula where sedimentation heavily impacts reefs. Skeletons from deceased gorgonians are often the tallest remaining structures after sediment deposition and reef burial; these parazoanthids colonize nearly all of them. This location represents a range extension of about 30 km to the north.

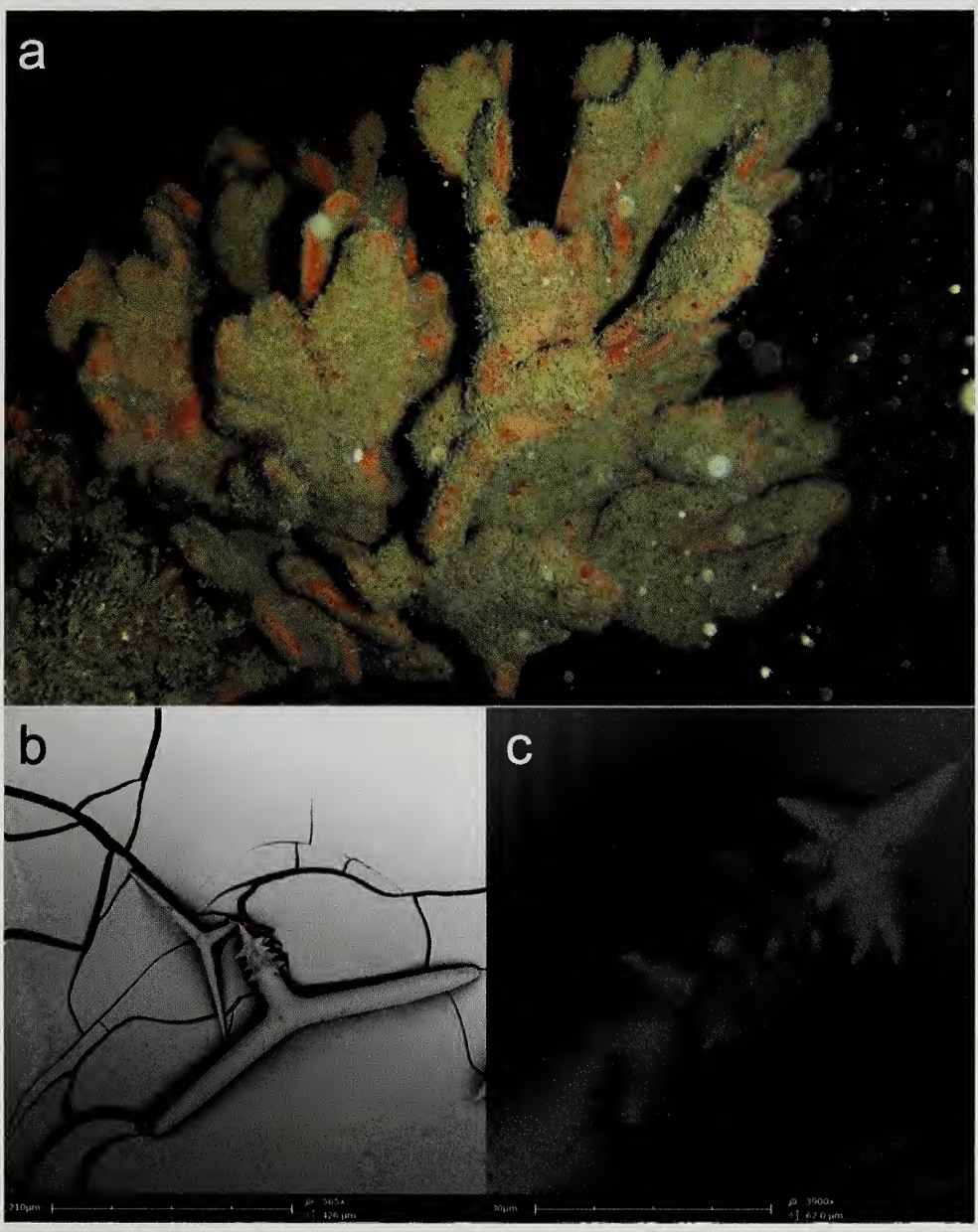

Fig. 4. (a) Mitten sponge (*Trikentrion helium*) from Ridges, Palos Verdes Peninsula, CA at 17 m depth on 3 Jul 2013. (b,c) SEM images of spicules from *T. helium* showing diagnostic triacts with only one spined ray. Photos and imaging by J.P. Williams.

Phylum Echinodermata
Class Echinodea
Order Spatangoida
Family Loveniidae

Lovenia cordiformis Agassiz, 1872, heart urchin (Fig. 5d)

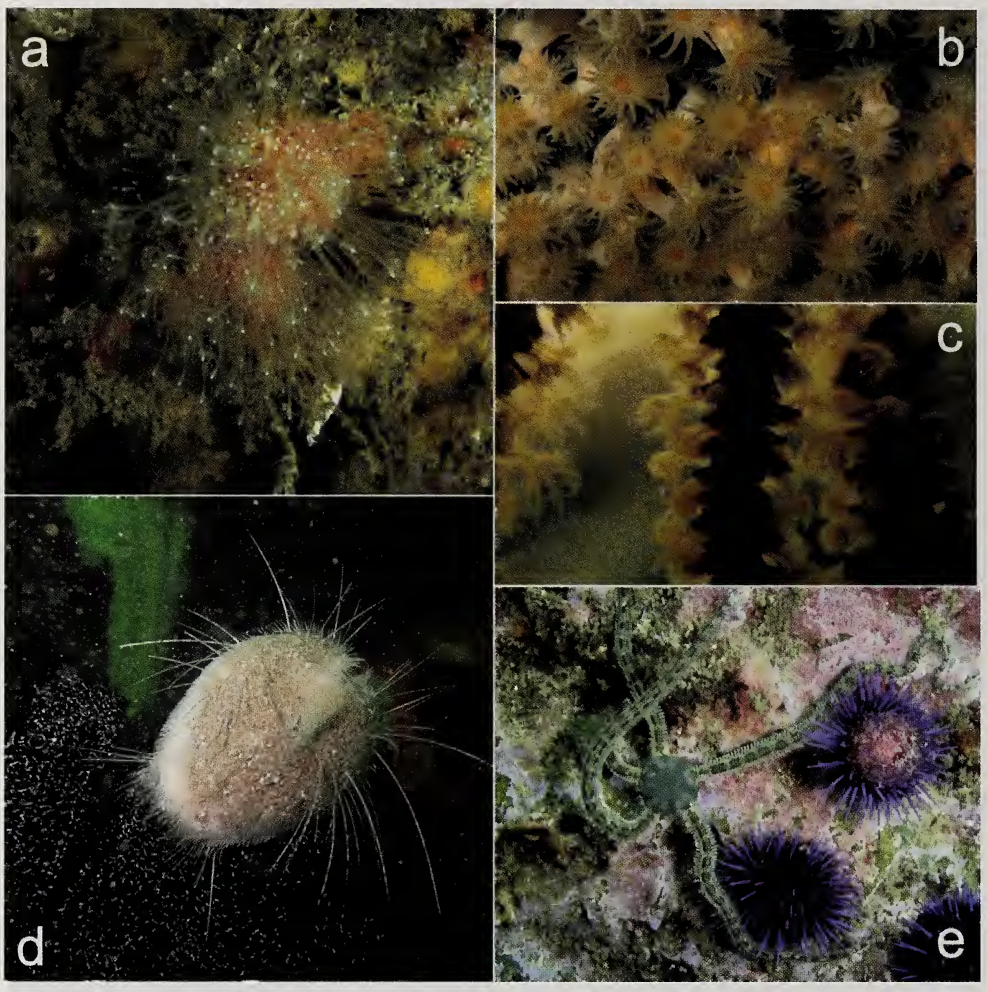

Fig. 5. (a) Hedgehog hydroid (*Schuchertinia milleri*) from Long Point, Palos Verdes Peninsula, CA at 13 m depth on 22 August 2012; (b) luminescent parazoanthid (*Savalia lucifica*) attached to the skeleton of a dead California gorgonian (*Muricea californica*; c) from Abalone Cove, Palos Verdes Peninsula, CA at 17 m depth on 27 March 2015; (d) heart urchin (*Lovenia cordiformis*) from KOU Rock, Palos Verdes Peninsula at 15 m depth on 2 October 2013; (e) ringed brittlestar (*Ophionereis annulata*) from Honeymoon Cove, Palos Verdes Peninsula at 5 m depth on 22 June 2016. Photos by J.P. Williams.

Previous reported range.—San Pedro, CA to Colombia and Galapagos Islands (Gotshall 2005; Muñoz and Lodoño Cruz 2016).

New record.—KOU Rock (between Bunker Point and Whites Point), Palos Verdes Peninsula, CA; 15 m depth; 2 October 2013.

Remarks.—This observation represents a very small range extension to the north, but also clarifies the limit as a coastal location rather than a city. The urchin was found buried in sand during buried reef sediment depth surveys when it was struck by an air jet probe.

Class Ophiuroidea

Order Ophiurida

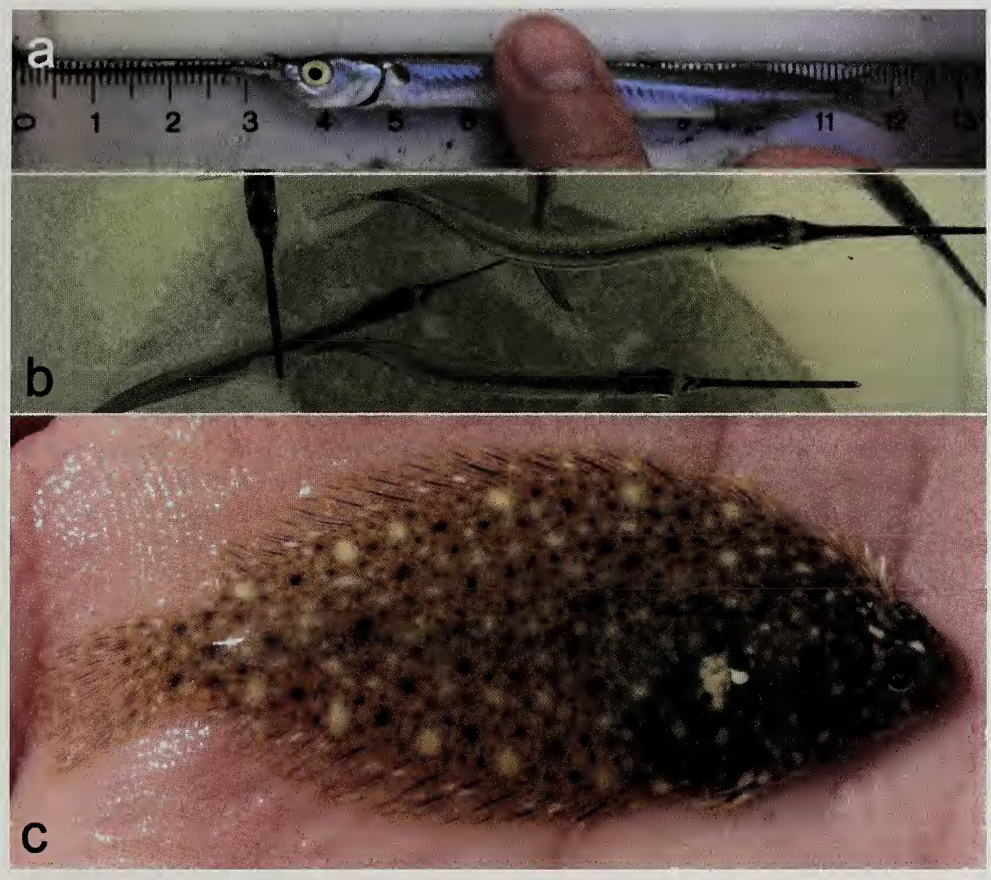

Fig. 6. (a) California halfbeak (*Hyporhamphus rosae*) from Mother's Beach, Marina del Rey, CA captured by beach seine on 24 October 2017 being measured (photo by D. Kirk) and (b) swimming in a bucket (photo by C. Pollock); (c) butter sole (*Isopsetta isolepis*) from Inner Cabrillo Beach, San Pedro, CA captured by beach seine on 2 April 2013. Photo by D.J. Pondella.

Family Ophionereididae

Ophionereis annulata (Le Conte, 1851), Ringed Brittlestar (Fig. 5e)

Previous reported range.—San Pedro, CA to Ecuador and Galapagos Islands (Ricketts and Calvin 1962).

New record.—Honeymoon Cove, Palos Verdes Peninsula, CA; 5 m depth; 22 June 2016.

Remarks.—These brittle stars were found sheltering underneath urchin spine canopy with mixed cobble, and represent a range extension of under 15 km, but also clarifies the limit as a coastal location rather than a city.

Phylum Chordata
Class Actinopterygii
Order Beloniformes
Family Hemiramphidae

Hyporhamphus rosae (Jordan and Gilbert, 1880), California halfbeak (Figs. 6a and 6b)

Previous reported range.—Santa Ana River, CA to Mazatlan, Mexico (Miller and Lea 1972).

New record.—Mother's Beach, Marina del Rey, CA; intertidal; 24 October 2017.

Remarks.—A total of 22 individuals from 7-13 cm SL were captured in four beach seining replicates during an Occidental College Biology 260 field trip, and represent a range extension of approximately 60 km.

Order Pleuronectiformes
Family Pleuronectidae

Isopsetta isolepis (Lockington, 1880), butter sole (Fig. 6c)

Previous reported range.—Ventura, CA to Southeastern Bering Sea and Aleutian Islands (west to Amchitka Island, AK) (Kramer et al. 2008).

New record.—Inner Cabrillo Beach, San Pedro, CA; intertidal; 2 April 2013.

Remarks.—A total of four juveniles (all approximately 3 cm SL) were captured in two beach seining replicates from a beach inside the Port of Los Angeles during an Occidental College Biology 356 field trip, and represent a range extension of approximately 110 km. All four individuals are stored in the museum collection in the Moore Laboratory of Zoology at Occidental College (VRG C39-2727).

Discussion

Fourteen species were observed and documented outside of their published range during these surveys including six algal species (five to the south, one to the north), six invertebrate species (one to the south, one to the mainland, and four to the north), and two fish species (one to the south, one to the north). The large-scale nature of these surveys in concert with the extended time frame of the monitoring programs (from the SCSR baseline through 2017) allowed for an extensive look at the nearshore subtidal and intertidal fauna in the region. The range extensions documented here are certainly, at least in part, a product of the large swings in oceanographic conditions throughout the SCB as evidenced by range extensions to both the north and south. The intensive, multi-agency, collaborative surveys performed as a product of MPA baseline monitoring provided greater opportunity for more thorough sampling of these habitats and a more accurate baseline for species distributions. We cannot be certain that these new locality observations are permanent and true range extensions, nor that they would not have been noticed in the past had there been similarly intensive sampling efforts. In fact, utilizing a modified version of a rapid assessment classification (Robinson et al. 2015) resulted in a high confidence for a true range extension only for *Savalia lucifica* (Table 1). Three macroalgal species were classified as moderately confident, while all other species were classified as low confidence. Large magnitude poleward shifts in species distributions are predicted for the west coast of North America in concert with strong, along-shore isotherm shifts (Morley et al. 2018), and with more frequent and expansive surveys being performed, further range extensions (in terms of distance and number) are expected in the near future.

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Cover: SEM image of spicules from a Mitten sponge (*Trikentrion helium*). Photo by J.P. Williams.